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LIFE HISTORY OF HYPOCREA ALUTACEA.[1]

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(WITH PLATES XIV–XVI)

Hypocrea alutacea (Pers.) Tul. is an interesting plant, not only on account of its history, but because of its peculiar form and color characters, taken in connection with its structure. In shape it is like a club or spatula, one to three inches high, resembling in form other members of the old genus Sphaeria now placed in the genera Xylaria and Cordyceps. It differs from the Xylarias in not being black, as well as in differences of texture and structure. It resembles more nearly a simple Clavaria, in which genus it was first placed as *Clavaria simplex* Schmiedel.[2] It resembles also a Cordyceps, in which genus it has also been placed, and it is even said to grow sometimes on insects. Some forms are also strikingly like species of Spathularia among the Discomycetes. To the collector, therefore, unacquainted with the plant, when he first finds it, it calls forth various emotions, running all the way from admiration of its simple lines of beauty to a possible belief that it is a "brand" new fungus, then to a temporary location in the wrong genus. But an examination of the spores shows at once its relation to the genus Hypocrea. The larger number of species of Hypocrea either form low cushions, or extended incrustations on decaying organic matter, or they are parasitic on the surface of the larger fungi, resembling in this respect some of the species of Hypomyces.

[1] Contributions from the Botanical Department of Cornell University no. 103.

[2] Icones et Analyt. 18–26. *pl. 4, fig. 2, pl. 5, figs. 1–3.* 1762, according to TULASNE, Selecta Fung. Carp. **3**:35. 1865.

The earlier students looked upon this fungus as an autonomous plant with an erect clavate stroma; among them are the following. PERSOON[3] first described it as *Sphaeria alutacea*. SOWERBY[4] discovered it in 1783, and described it in 1799 as *Sphaeria clavata*. SCHUMACHER[5] followed Persoon. ALBERTINI and SCHWEINITZ[6] in 1805 record it as growing on decaying Alnus. NEES VON ESENBECK[7] in 1816 placed it in his subdivision of clavate Sphaeriae (*Keulen-sphärien–Sphaeriae Clavaeformes*) which he says are like a simple Clavaria, or Geoglossum in which the ascus layer has changed into perithecia. The first species which he places in this group is the leather-yellow Sphaeria, *S. alutacea* Pers. He states that it grows on the ground in fir woods. FRIES[8] in his treatment of the genus Sphaeria places it in the tribe Cordyceps, series Hypocrea, as *Sphaeria alutacea*.

Those also who have placed it in the genus Cordyceps regarded it as an autonomous plant. LINK[9] first placed it in Cordyceps as *C. alutacea* and was followed by FRIES.[10] It was distributed under two different numbers in *Rab. Fung. Europ. Ex.* 132 (1860) from pine woods, England, as *C. alutacea* (Pers.) collected by C. E. BROOME, and no. 246 (1860) from mossy woods, near Leipzig, as *C. alutacea* β *albicans* (Pers.), a lighter form, from alutaceus to white, according to the note in connection with the specimen. BERKELEY[11] under *Cordyceps alutacea* Fr. says "clavate, tan colored or nearly white, head confluent with the stem. In fir woods amongst leaves and furze," and his figures show a variation in size between stout and slender forms. QUÉLET[12] in connection with *Cordyceps alutacea* (evidently using the name employed by FRIES in *Summa Veg. etc.*)

[3] Obs. Mycol. **2**:66. *pl. 1, fig. 2, a, b, c.* 1797. Comm. de fung. clavif. 12. 1797.

[4] English Fungi **2**: *pl. 159.* 1799.

[5] Enum. Pl. Sellandiae **2**:175. no. 1343. 1803.

[6] Consp. Fung. Lusat. Sup. 1. 1805.

[7] System der Pilze 289. *pl. 40, fig. 304.* 1816.

[8] Syst. Myc. **2**:325. 1823.

[9] Handb. z. Erkenn. der Gewächse 3:347, no. 5. 1833.

[10] Summa Veg. Scand. 381. 1849.

[11] Outlines Brit. Fungol. 382. *pl. 26, fig. 6.* 1860.

[12] Champignon du Jura et des Vosges 487. 1869.

says that the spores are cylindrical and two-celled, the upper globose, the lower oblong, and in a footnote says that from the texture and fructification the species would belong rather to Hypocrea. It grew among needles of *Pinus sylvestris*. WINTER[13] records *C. alutacea* QUÉLET from the Jura mountains and says the spores are needle-like, with many segments, and 40–50 μ long! Evidently this is not QUÉLET'S species. CURREY[14] says it is a Cordyceps with the fructification of Hypocrea.

The TULASNES[15] in their classical studies forty years ago pointed out the resemblance in the habit of this plant to that of certain species of Hypomyces, as *H. lateritius* Fr., and *H. lactifluorum* Schw., which are parasitic on species of Lactarius, the *H. lactifluorum* deforming white species of Lactarius and giving them a bright red color. With this interpretation of the dual nature of the fungus they were led to believe that *Hypocrea alutacea* was in a similar way parasitic on a certain species of the simple clavarias, viz., *Clavaria ligula* Schaeff. Their interpretation of the dual nature of the fungus has since been generally conceded to be correct. SACCARDO,[16] WINTER,[17] and other systematists have followed them in considering it as parasitic on either *Clavaria ligula* or Spathularia, on which latter host BROOME reported it according to SACCARDO.[18] It has been reported by DAY[19] in North America also on an undetermined species of Spathularia, where he says, "Apparently parasitic on Spathularia" and reference is made to PECK, Rept. N. Y. State Mus. **26**:84. 1874, where the plant is merely listed as growing on fallen leaves. WINTER (*l. c.*)

[13] Rabenhorst's Krypt. Fl. etc. Pilze **1**²:149. 1885.

[14] Synopsis of the fructification of the compound Sphaeriae in the Hookerian Herbarium. Trans. Linn. Soc. London **22**:264. 1858.

[15] Selecta Fung. Carp. **3**:35. 1865.

[16] Sylloge Fungorum **2**:530. 1883.

[17] Rabenhorst's Krypt. Flora, etc., Pilze, **1**²:142. 1887.

[18] According to SACCARDO *l. c.* See also ELLIS, N. A. P. 89. 1892, where its occurrence on *Spathularia flavida* is ascribed to BROOME.

[19] DAY, DAVID F., A catalogue of the native and naturalized plants of the city of Buffalo and its vicinity. Bull. Buff. Soc. Nat. Sci. **4**:161. 1882. The reference in FARLOW'S Host Index (see FARLOW & SEYMOUR, A provisional host index of the fungi of the United States 175. 1891) to *H. alutacea* as parasitic on Spathularia, Dr. FARLOW writes me, was made from DAY'S catalogue, and he adds that he has never found it on Spathularia.

points out that the stroma of the parasite is completely merged with that of the host, and that only the upper clavate part of the host bears perithecia, while the stem is free or bears the conidial form.

Some very discriminating observers, however, have dissented from TULASNE'S interpretation of the dual nature of the fungus, though no proof has been brought forward to demonstrate either its parasitic nature or its autonomy. CORNU[20] as early as 1878 collected several specimens on decaying leaves of *Abies picea* in a forest in the environs de Pontarlier. He searched diligently for specimens of *Clavaria pistillaris* of which he says *Clavaria ligula* is like a reduced form. He found none in the neighborhood of the *Hypocrea alutacea*, nor could he find any evidence that it grew either as a parasite or saprophyte on insects or on any subterranean fungus. Although he cannot say with certainty, he does not think the plant can be regarded as a parasite or that it develops at the expense of *Clavaria ligula*. He regards it rather as analogous in habit and nutrition to species of Xylaria which grow, some on wood, others on leaves and humus, and he cites an exotic species *X. compuncta* Jungh., as resembling in some respects the *Hypocrea alutacea*, the plant being alutaceous to pallid, but dark punctate from the perithecia.

In 1894 SCHROETER,[21] a keen and discriminating student of the fungi, also took issue with the prevalent theory that *Hypocrea alutacea* was a parasite on *Clavaria ligula*. He says that this is not the case with the forms which grow in Schlesien. He says the fungus grows on wood as ALBERTINI and SCHWEINITZ have pointed out, and as he himself has observed at Breslau, while *Clavaria ligula* grows on needles of conifers. LINDAU[22] also in his treatment of the Hypocreales follows SCHROETER'S judgment rather than that of TULASNE and WINTER. FARLOW[23] records collecting *Hypocrea alutacea* at Shelburne, N. H., under *Pinus strobus* where was also growing *Clavaria ligula*, but he was unable to trace any direct connection between the two.

There is thus a reasonable doubt probably as to which horn of

[20] Note sur l'*Hypocrea alutacea* Pers. Bull. Soc. Bot. de France **26**:33–35. 1879.

[21] Krypt. Fl. Schles., Pilze, Zweite Hälfte **3**:272. 1894.

[22] Engler und Prantl Pfl. Fam. **1**[1]:365. 1897.

[23] Lloyd's Myc. Notes 9 (195):110. 1902.

this dilemma we shall choose. At least none of these students has left us any evidence which can be considered proof of one or the other of the theories as to the nature of *Hypocrea alutacea*.

My first acquaintance with the plant was in August 1901, when Mr. A. M. FERGUSON, one of the students in my laboratory, collected several specimens growing on very rotten wood in one of the forested gorges at Ithaca, N. Y. In looking up the literature at the time I was impressed with the diversity of opinion on the subject, as well as the lack of any attempt at experimental proof one way or the other in support of the theories advanced. It occurred to me that perhaps here was an opportunity to settle by simple experiment this dispute of a century. At least the trial could be made. Accordingly the plants were placed over night in a new and clean pasteboard box, covered. On the following day I found that the bottom of the box was nearly covered with numerous ascospores which had been shot out of the perithecia during the night. There was also a thick and loose covering of the spores over the fruiting portion of the fungus as the plants lay in the box.

For culture media I employed sterilized slices of a species of Lactarius which had been prepared a few days before for culturing *Nyctalis asterophora*. These slices were in test tubes and about half covered with water. With a sterilized platinum needle, transfers of ascospores were made from the fresh pile on the plants to the agaric substratum in the tubes. Twelve tube cultures were started. With this number it was quite probable that from the fresh pile of spores several plantings could be made which would be pure. If the spores should grow, and the mycelium mature perithecia, there would likely be some indication as to whether *Hypocrea alutacea* is single or dual in its nature. If single, then we would expect the development of a clavate stroma in the pure culture. If dual, the stroma would be spread over the surface of the dead slice of the agaric. At the same time dilution cultures were made in agaric agar-agar in Petri dishes. None of the spores germinated in them, however.

In a week's time I left Ithaca for the mountains of western North Carolina. At the time of leaving there was very little evidence of any growth in the tube cultures, although *Nyctalis asterophora* spores, sowed at the same time, produced a mature crop of plants in a week.

It is interesting now to note the form of the individual plants from which cultures were attempted. One of them resembled in shape *Spathularia flavida*, as if it might have been somewhat arrested in development (*pl. XIV, fig. 1, b*), while others resembled *Clavaria ligula*, and one was more or less deformed, curved strongly, and with a broad groove on the concave side. These forms would seem to satisfy the wish of the most ardent advocate of the parasite theory who does not attempt to put the theory to the crucial test. In structure, however, there was no indication of a difference of the structural elements such as one might expect to find were the plant parasitic on *Clavaria ligula* or Spathularia, and an advocate of this theory would be compelled to join WINTER in saying that the parasite and host were completely merged. It should also be said that no normal specimens of *Clavaria ligula* or of Spathularia were at the time growing in the immediate vicinity of the Hypocrea.

Of course, during the next five weeks, while collecting fungi in the mountains of North Carolina, I was on the lookout for *Hypocrea alutacea* and its relation to either of these supposed hosts. I found one day a large colony of *Spathularia clavata* growing under a white pine tree. The Spathularia extended over an area of 75 to 100 square feet. Among the Spathularia plants I found four or five specimens of *Hypocrea alutacea*. These were growing not on wood, but apparently from decaying organic matter among the pine needles, and, as far as one could judge, their habitat was the same as that of the Spathularia. Singularly, the form of these specimens was quite regular. The form was not, however, similar to that of the Spathularia, but more like that of *Clavaria ligula*. But no specimens of the latter plant were found growing in the immediate vicinity. No other specimens were found during that season.

On returning to Ithaca in the latter part of September, I hastened to examine my tube cultures of the Hypocrea. There were two perfect specimens, one in each of two tubes. Both of them possessed the Clavaria-like form and stood up clearly from the substratum. Here, then, were two specimens of *Hypocrea alutacea* in pure culture from the ascospores, and the form in general like that of the plants found in their natural environment. Moreover, they were certainly growing as saprophytes and not as parasites. This, I believe, demon-

strates that *Hypocrea alutacea* is an autonomous plant,[24] and it is the first proof we have that it is not of a dual nature, parasitic on *Clavaria ligula* or Spathularia.

It might still be contended that the plants which I found growing among the pine needles along with the Spathularia in North Carolina, were of a different species from those growing on rotting wood at Ithaca, N. Y. Especially might this view be taken since FRIES[25] describes *Hypocrea alutacea* as growing among needles of the fir, and describes a form *turgida*, growing on rotting wood. SCHROETER (*l. c.*) when he states that according to his observations *Hypocrea alutacea* grows only on wood, cites FRIES'S disposition of the two forms and says that possibly the form on wood is a different species which should be called *Hypocrea turgida*. It seems to me, however, more rational to attribute the slight variation in form to a recognizable range of variation in the species, either inherent in the species, or attributable to the change of substratum. According to FRIES the more robust form grows on wood. The form on wood at Ithaca was more robust than the form among the pine needles in North Carolina. But I have collected a form on wood in North Carolina of the same size as, or even smaller than, those among the pine needles. However, the forms which I grew in pure culture on sterilized Lactarius were more slender and were more like those found among the pine needles, although their direct parentage was from the robust form from wood.

The wood forms are found on half-decayed wood, and also on very rotten wood. From this condition of the substratum it is an easy transition to wood mold or leaf mold, in the adaptation of the plant to a limited range in the variation of the condition of the same general substratum. Since the plant can grow as a saprophyte on dead mushrooms, as shown by the pure cultures, it might be possible that sometimes in the forest it grows as a saprophyte on decaying Spathularia or *Clavaria ligula* buried among the leaves. It is very probable, however, that there is a range in the habitat of the species from wood

[24] These facts, as well as photographs of *Hypocrea alutacea* from the wood substratum and in pure cultures were presented before the Botanical Society of America at the Washington meeting, December 30, 1902 to January 1, 1903.

[25] Syst. Myc. **2**:325. 1823.

or leaf mold to very rotten wood and to wood in a one-fourth to a one-half decayed condition. This range would be represented by a habitat life curve, which rises from the leaf or wood mold in the ground to the upper limit on the decaying wood, influenced, to some extent at least, by other conditions of environment. Or if the wood habitat is the normal one, then the curve would descend according to conditions to the wood mold and leaf mold in the ground. This range in habitat is manifested by a large number of the higher fungi. The curve rises or descends from the normal habitat according to the peculiarities of each species and according to the modifying influences of other environmental conditions.

The history of *Hypocrea alutacea* has become more interesting by the publication of *Hypocrea Lloydii* Bresadola in 1902, which was collected by C. G. LLOYD in West Virginia, in the summer of 1901. Following the brief description, BRESADOLA notes[26] that the species is very interesting, with the aspect of Cordyceps but fructification of Hypocrea. The photograph published at the time, with the description, suggested to me that the plant might be identical with *Hypocrea alutacea*, and I inquired of Mr. LLOYD if he did not think this to be the case. My letter was communicated to Dr. BRESADOLA, and his reply was published in a note by Mr. LLOYD[27] in September 1902. These notes from BRESADOLA are very interesting. In the first place he was not familiar with *Hypocrea alutacea*, since he had never seen the plant; but accepting, as was natural under the circumstances, TULASNE'S interpretation of its parasitic nature, the plant communicated to him by Mr. LLOYD was believed to be a new species in the section Podocrea of SACCARDO,[28] a section formed to include species of Hypocrea with a vertical stroma. BRESADOLA also compared the structure of the stroma of *H. Lloydii* with the structure of both *Clavaria ligula* and *Spathularia flavida*, and finds it very different from either. He concludes by saying that if *Hypocrea Lloydii* is really identical with *Hypocrea alutacea*, a species unknown to him, then he does not believe in the parasitic nature of the latter. At this time LLOYD (*l. c.*) accepted BRESADOLA'S note as

[26] BRESADOLA, G., *Hypocrea* (Podocrea) *Lloydii* n. sp., Lloyd's Myc. Notes 9 (176):87. 1902.

[27] *Idem* 10 (183):99. 1902.

[28] Syll. Fung. **2**:530. 1883.

indicating that *H. Lloydii* and *H. alutacea* were identical. Later, however, he states[29] that PATOUILLARD believes *H. Lloydii* "is a good species and very different from *H. alutacea*." LLOYD saw specimens of *H. alutacea* at the Herbarium of the Museum of Paris and said that he does not think it possible the two plants are the same.

Through the courtesy of Dr. BRESADOLA I have had the opportunity of seeing the type specimen of *Hypocrea Lloydii*, and I consider it identical with *Hypocrea alutacea*. In *plate XVI* are photomicrographs of a section from the dried specimen through a portion of the clavula showing the perithecia, and in *plate XV* are similar photomicrographs of the plant collected at Ithaca, the material having been fixed while it was fresh. The only differences which can be observed are those which are due to the difference in the age of the plants at the time they were collected. The specimen of *H. Lloydii* was quite mature, as shown by the more advanced stage of disappearance of asci or freedom of spores from the asci. The perithecia are therefore somewhat older and larger, and are thus crowded against each other, and flattened on the sides where they are closely packed.

The form of the plants themselves at first sight appears different, *H. Lloydii, plate XIV, fig. 3*, being long and slender, while those of *H. alutacea, plate XIV, fig. 1*, are stouter. But the individuals of *H. alutacea* which were all growing close together differ more among themselves than the *H. Lloydii* does from the individual of *H. alutacea* at the left. It is unfortunate that this specimen is curved, and therefore that not all of the stem is shown in the photograph. However, the long stem of the single individual of *H. Lloydii* (the species is based on the single specimen collected), as one can see from an examination of the photograph, is due to the fact that the lower half of it was in the leaf mold, the stroma having its origin about 4^{cm} below the surface of the leaf mold. It is a matter of common observation in the case of many stipitate fungi to find the stem considerably elongated under such conditions. I have seen notable examples in the case of *Collybia radicata*, *Clavaria ardenia*, and others, the length of the stem depending on the depth of the substratum below the surface. The plant is quite variable also in regard to its stoutness. This is perhaps also due to some extent to con-

[29] Mycological Notes 15 (264): 156. 1903.

ditions of environment, though at present it is difficult to say just what conditions produce a robust form and what ones produce a more slender form. SCHROETER (*l. c.*) found the robust form on decaying wood, and suggested that perhaps it might be a different species which should bear the name given by FRIES (*l. c.*) to the robust form, *β turgida*. Along with this variation in the robustness of the plant, there is a variation in the direction of a deformity where the clavula may be flattened, triangular, curved, etc., which has led some observers to question the identity of some of the forms described and figured by different writers. That the form on wood is not always robust is well shown in a small and slender specimen which I collected several years ago on a log in the mountains of North Carolina. The log was not much decayed, and possibly the conditions of nutrition were not so favorable as in the case of much decayed wood, which was the condition of the substratum on which the robust Ithaca specimens grew (*plate XIV, fig. 1*). The variation in these individuals growing close together is sufficient to show what the range in form may be in specimens from different localities.

There is also a variation in color. The plant is usually said to be "tan" color, or "leather" color (to which the specific name *alutacea*, refers), or "pallid," and sometimes "white." White forms gave rise to the variety *β Sphaeria albicans* Pers.[30] BERKELEY[31] describes the plants as tan-colored or nearly white. The color very likely depends very largely on the age of the plants when collected. The Ithaca plants here described were entirely white when collected. But the fact that the asci are so well preserved and most of the spores are still in the asci shows that the plants were just ripening. The plants in pure culture which had their parentage directly from the white ones, had white stems, but the clavulae were tan-colored at the time they were photographed, probably because they were quite well ripened. From the general character of the plant we should expect that the young clavula would be white in all cases, and that the color is an attribute of ripening or age, and it is then reasonable to expect, even in specimens with well-formed spores, that as the plants are collected there would be a sufficient variation in age to account for the color variation observed.

[30] Syn. Method. Fung. 2. 1801. [31] Outlines British Fungology 382. 1860.

That the American plants are identical with European ones is evident from an examination of the specimens in Raben. Fung. Europ. Ex. nos. 132 and 246 mentioned above, and I had the opportunity also, while in Paris in October 1903, of personally examining, through the courtesy of M. HARIOT, the specimens of *Hypocrea alutacea* in the herbarium of the Museum of Paris, among which were some specimens from TULASNE'S herbarium.

The spores in this species, while presenting slight variations, are quite peculiar. As is well known, the spores in the genus Hypocrea are eight in an ascus uniseriate, and each one is two-celled, but at maturity the constriction at the septum is very strong, and the segments of the spore are separated so that the ascus appears to have sixteen nearly globose or oval spores in a single row. The separation of the two segments of the spore is one of the characters distinguishing Hypocrea from Hypomyces, while short, two-celled spores distinguish *Hypocrea alutacea* from species of Cordyceps, which have long filiform spores separating at maturity into numerous segments. CORNU (*l. c.*) also points out that species of Cordyceps grow on living or recently dead insects or plants, while *Hypocrea alutacea* grows on decaying wood and leaves, though this distinction may not hold good, since as a saprophyte *Hypocrea alutacea* might grow on dead insects under certain conditions, and it has even been reported on insects. The two segments of the spores of *Hypocrea alutacea* are somewhat different in form. They are usually described as 'superior cell globose, inferior cell oval, or suboval, or oblong.' BRESADOLA[32] does not call attention to the difference in shape of the two segments in *Hypocrea Lloydii*, but says "articuli subcuboideis subglobosi." But the two segments are different in form, as I have found by examination, and the spores in the photomicrograph, *plate XVI, fig. 9*, from *H. Lloydii* show very clearly this difference in form, a globose and oblong segment alternating throughout the chain formed by the juxtaposition of the spores in the length of the ascus. The upper segment (the one nearest the free end of the ascus) is globose or subglobose or subcuboid, while the lower segment is elongated slightly in the direction of the axis of the spore and is usually not quite so broad as the upper segment. The lower segment is very

[32] Lloyd's Myc. Notes 9 (176):87. 1902.

short oblong, or suboval. The shape of the segments is exactly the same in the Ithaca specimens of *Hypocrea alutacea* as can be seen in *plate XV, fig. 6*, a photomicrograph. The spores measure from 4.5–5.5 μ long $\times$ 2.5–3 μ wide. The upper segment is 2.5–3 μ in diameter, and the lower one is 2.5–3.5 μ long $\times$ 2–2.5 μ in diameter. After fixing and imbedding in balsam the measurements are somewhat smaller than here given.

The spores lie very close together, end to end in the ascus, so that the sixteen segments often appear connected into a necklace-like string. They appear sometimes to adhere to some extent even after escaping from the ascus, but the individual spores can be determined usually by the difference in shape of the two segments.

There is one other question in connection with this plant which it is now necessary to consider. In what genus shall the species be placed? Typical species of Hypocrea have a crustaceous, or cushion-shaped or hemispherical stroma, while the stroma of *Hypocrea alutacea* is vertical and elongated. Such a marked difference in the form of the plant is usually regarded as representing a different generic type, just as the erect stromata of the species of Xylaria represent a different generic type from the crustaceous, cushion-like or hemispherical stromata of Hypoxylon. SACCARDO[33] used the name Podocrea as a subgenus for the species of Hypocrea with a vertical stroma, and included three species: *Cordyceps larvata* Mont.,[34] *C. brevipes* Mont.,[35] and *Hypocrea Petersii* B. & C.[36] *Hypocrea alutacea* he did not place in this section, since he followed the TULASNES in believing it parasitic on *Clavaria ligula*. LINDAU[37] in 1897 raises Podocrea to generic rank, and places *Hypocrea alutacea* as the first species, although KARSTEN[38] had founded the genus Podostroma five years earlier, for a species which he found on a larva of a decaying insect among mosses in Finland. *Podostroma* Karsten, therefore, should have precedence over *Podocrea* (Sacc.) Lindau, and it is unfortunate that LINDAU did not use the name *Podostroma alutacea*.

KARSTEN (*l. c.*) described one species, *P. leucopus*. The char-

[33] Syll. Fung. **2**:530. 1883.

[34] Syll. Crypt. no. 674, p. 200. 1856.

[35] *Idem* 676, p. 201. 1856.

[36] Grev. **4**:13. 1875.

[37] Engler und Prantl Pflanzenf. **1**[1]:364. 1897.

[38] Hedwigia **31**:294. 1892.

acters of this genus and species are so remarkably like those of *Hypocrea alutacea* that it may be well here to give a translation both of the generic and specific diagnosis.

PODOSTROMA n. gen.—Character of the Hypocreaceae. Stroma stipitate, clavate, erect, entomogenous, fleshy, bright colored. Perithecia immersed in the stroma. Asci cylindrical, 16-spored. Spores sphaeroidal, hyaline. Paraphyses none.

Pod. leucopus n. sp.—Stromata solitary. Clavula bearing the perithecia obovoid to oblong, alutaceous-pallid, about 6^{mm} long and 4^{mm} stout. Stipe equal, terete, flexuous, about 5^{cm} long and 2^{mm} stout, white. Perithecia in the periphery, spheroidal, immersed, opening by a pore. Asci cylindrical, subsessile, about $75\times4\,\mu$. Spores 16, monostichous, spheroidal, hyaline, $2–3\,\mu$ in diameter. On larva of certain putrid insects among mosses in coniferous woods, Syrjãås, October.

The specimens of no. 246 Rabenh. Fungi Europ. Ex. in the herbarium of the Botanical Department here represent very well in form and size the *Podostroma leucopus* described by KARSTEN. The plants are slender when dry, 3^{cm} high, the stem less than 1^{mm} in diameter and was likely not more than 2^{mm} when fresh. The clavula is obovoid, about 3.5^{mm} long a trifle over 2^{mm} in diameter, and was very likely stouter when fresh. The plants of no. 132 Rabenh. Fungi Europ. are much stouter, the stem more than 2^{mm} in diameter when dry, short, and the clavula elongate and tapering gradually into the stem. The spores in no. 246 are mostly cuboidal in the specimen examined, and the asci show that they are young. Many of the asci give the appearance of having sixteen equal subcuboidal spores. But occasionally, where they are a little older, every alternate one is slightly elongated and narrowed, so that it is suboval or short suboblong. Still younger asci show the plasma content divided into eight parts, and then occasionally one of these young spores is divided into two cells. This indicates clearly that here are eight spores. The second division is so prominent and the constriction so deep it gives soon the appearance of sixteen spores. It would appear that in the later growth of the spores the inferior segment elongates slightly at the expense of its diameter. The specimens collected at Ithaca show the same character from the individuals when asci are just maturing the spores. The plasma is first divided into eight portions, showing that there are eight spores.

In older ones each of these is divided into two equal parts, and the inferior one is usually elongated slightly. But many asci which were dried at this stage show sixteen segments in a crowded chain, all of about the same form, and subglobose to subcuboidal. In a very few cases the spore is pyriform, divided into two cells by a cross wall cutting off the lower smaller cell without any perceptible constriction at the septum. It will be seen that the age of the asci and spores at the time of collection of the plant will vary, and consequently there will be a variation in the form of the spore segments. All may be subcuboidal and of the same size and form, or when older the inferior segment may be slightly elongated and narrowed, and the superior one will be globose to subcuboidal. They are so crowded also in the ascus that there is a tendency for them to cling into a chain or necklace, and this may be aided not only by a small amount of periplasm, but also by remains of the disintegrating ascus which are difficult to perceive.

If KARSTEN's plant had not been reported as growing on an insect, one would have no hesitancy in placing it in *Hypocrea alutacea*, for all the characters of form, color, and structure agree. The only difference is that of the substratum. The fact that it is reported as growing on a decaying insect, taken in connection with its agreement in form, structure, and color with *Hypocrea alutacea*, is rather strong evidence that this is only a further extension of the range of decaying organic matter on which the fungus grows. It should also be noted that *Podostroma leucopus* was found in coniferous woods, and *Hypocrea alutacea* is usually found under pines or spruces, though it occurs on decaying wood of the broad-leaved trees, as is seen from its occurrence on Alnus cited above, and ELLIS[39] reports it at Newfield, N. J., on "bark of a decaying (maple?) limb, lying on the ground."[40]

There remains to be considered the standing of the subgenus *Fracidia* proposed by FRIES[41] in 1849 for certain exotic species of

[39] Jour. Myc. **2**:50. 1886.

[40] The Tulasnes find a conidial form (Select. Fung. Carp. **3**:38. *pl. 4, fig. 4.* 1865) *Verticillium globuligerum* Sacc. (see Syll. Fung. **2**:530. 1888) growing on the lower part of the stem, which they regard as the conidial stage of *Hypocrea alutacea*. I have not seen it.

[41] Summa Veg. Scand. 381, 382. 1849.

Xylaria. In a footnote on page 381 of his *Summa Veg. Scand.* he definitely cites *Xylaria flabelliformis* (Schw.) B., *X. pumila* Linn., *X. comosa* and *X. collabens* Mont., as pertaining to the subgenus Fracidia. In 1864 he transfers *Sphaeria alutacea* Pers., which he had formerly placed in Cordyceps (*l. c.*), to the subgenus Fracidia, where he writes it as follows: "*Sphaeria s. Fracidia alutacea*,[42] but differing in color from the species of Xylaria first placed in this subgenus, as *Cordyceps militaris* differs from *C. ophioglossoides*." This short paper by FRIES is a critical review of CURREY'S *Synopsis of the fructification of the compound Sphaeriae of the Hookerian Herbarium.*[43] CURREY (*l. c.*, 260) employs the genus Sphaeria, which is divided into sections and divisions. FRIES in his annotations on certain species (*l. c.*) merely follows CURREY in writing Sphaeria as the genus, the *s.* probably standing for subgenus. It is therefore difficult to see how "*Sph. s. Fracidia alutacea*" can be taken as raising Fracidia from subgeneric to generic rank, and if the name is to be employed for a genus it should be used for those species of Xylaria first ascribed to it by FRIES and cited above. The TULASNES[44] list *Fracidia alutacea* in their synonymy of *Hypocrea alutacea*, but this could not be taken as raising Fracidia to generic rank. *Podostroma* Karsten[45] (1892) is therefore the generic name to be employed for our plant, instead of *Podocrea* Lindau[46] (1897), although it was employed as a subgenus by SACCARDO (*l. c.*) in 1883; but SACCARDO did not include the *Hypocrea alutacea* in his subgenus. The International Botanical Congress at Vienna, June 1905, recommends that when the species of a subgenus are raised to generic rank, the name of the subgenus in which they were placed be employed, but this is a recommendation

[42] Adnotata ad Cel. Fr. Currey dissertationem; Synopsis of the fructification of the Sphaeriae of the Hookerian Herbarium in Act. Soc. Linn. Lond., Vol. XXII, pp. 257–86 et 313–35. Bot. Zeit. **22**:189, 190. 1864.

[43] Trans. Linn. Soc. London **22**:257–286. *pls. 45–49.* 1859; and "Synopsis of the fructification of the simple Sphaeriae," etc. *Idem* 313–335. *pls. 57–59.*

[44] Selecta Carp. Fung. 35. 1865. The reference is "in Schlechtendalii Ephem. Bot. Berol., t. XXII (1864), p. 189, n. 22," which is TULASNE'S way of referring to Bot. Zeit. of which SCHLECHTENDAL was an editor. I wish to acknowledge here the aid of Dr. FARLOW of Harvard University and Dr. BRITTON of the New York Botanical Garden in straightening out this reference.

[45] Hedwigia **31**:294. 1892.

[46] Engler und Prantl Pflanzenf. **1**[1]:364. 1897.

and therefore not mandatory. Fracidia, as shown above, was never raised to generic rank, and if it were to be it should be used for the species of Xylaria which FRIES first referred to it. KARSTEN might have used SACCARDO'S subgenus Podocrea in 1892, but since he founded the new genus Podostroma five years before LINDAU raised Podocrea to generic rank, Podostroma should stand. Furthermore it is very doubtful if any of the three species first placed by SACCARDO in his subgenus Podocrea are generically the same as *Hypocrea alutacea*, although SACCARDO[47] suggests that *Podostroma* Karsten appears to be very like his section Podocrea.

In the light of this study, then, the name to be applied to *Hypocrea alutacea* (Pers.) Tul. with its principal synonymy would be as follows:

Podostroma alutaceum (Pers.) Atkinson.

Clavaria simplex p. p. Schmiedel. Icon. et Analyt. 18–26. *pl. 4, fig. 2, pl. 5, figs. 1–3.* 1762, according to Tulasne.

Sphaeria alutacea Pers. Observ. Myc. **2**:66. no. 99. *pl. 1, fig. 2, a, b, c* 1797. Comm. de fung. Clavif. 12. 1797.

Sphaeria clavata Sowerby. Eng. Fung. **2**: *pl. 159.* 1799.

Sphaeria alutacea Alb. & Schw. Consp. Fung. Lusat. Sup. 1. 1805.

Sphaeria alutacea β Sphaeria albicans Pers. Syn. Method. Fung. 2. 1801.

Sphaeria alutacea Fr. and *β turgida* Fr. Syst. Myc. **2**:325. 1823.

Cordyceps alutacea Link. Handb. z. Erkenn. der Gewächse 3:347. no. 5. 1833.

Cordyceps alutacea Fr. Summa Veg. Scand. 381. 1849.

Cordyceps alutacea Berk. Outlines Brit. Fung. 382. *pl. 23, fig. 6.* 1860.

Cordyceps alutacea Quélet. Champ. Jura et d. Vosges 487. 1869.

Hypocrea alutacea Tul. Selecta Fung. Carp. **1**:62. 1861, and **3**:35. *pl. 4, figs. 1–6.* 1865.

Hypocrea alutacea Peck. Rept. N. Y. State Mus. **26**:84. 1894.

Hypocrea alutacea Cornu. Bull. Soc. Bot. de France **26**:33–35. 1879.

Hypocrea alutacea Sacc. Syll. Fung. **2**:530. 1883.

Hypocrea alutacea Winter, Rabenhorst's Krypt. Flora Deutschland, etc., Pilze 1^2:142. 1887.

? Podostroma leucopus Karsten. Hedwigia **31**:294. 1892.

Hypocrea alutacea Schroeter. Krypt. Flora Schles., Pilze, Zweite Hälfte **3**:272. 1894.

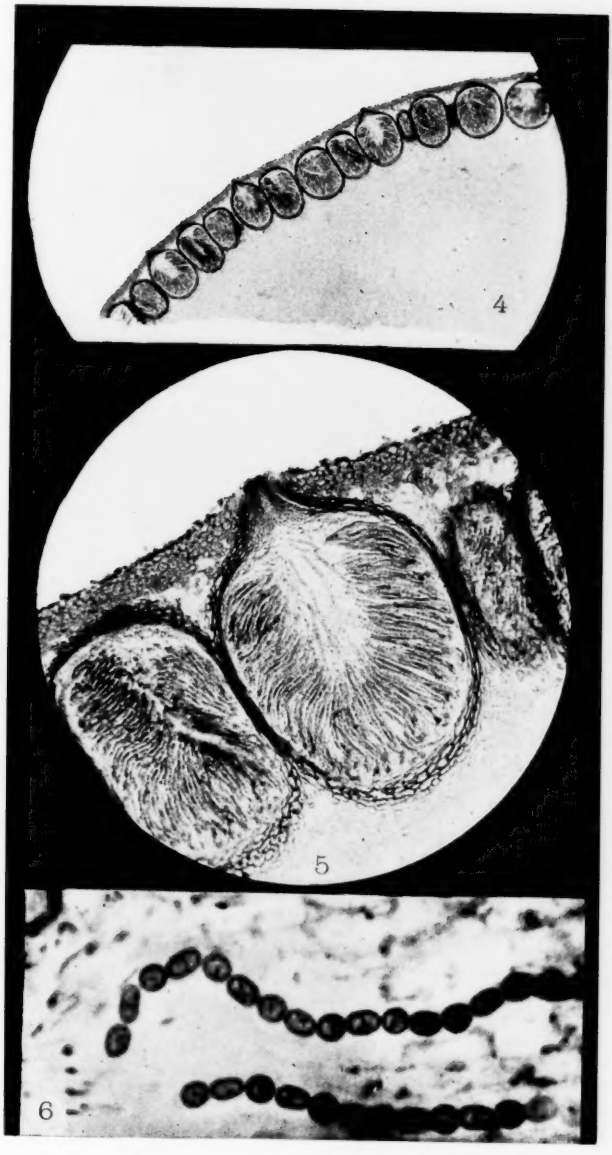
Podocrea alutacea Lindau. Engler und Prantl's Pflanzenf. 1^1:364. 1897.

Hypocrea Lloydii Bresadola. Lloyd's Mycolog. Notes 9 (176):87. *fig. 55.* 1902.

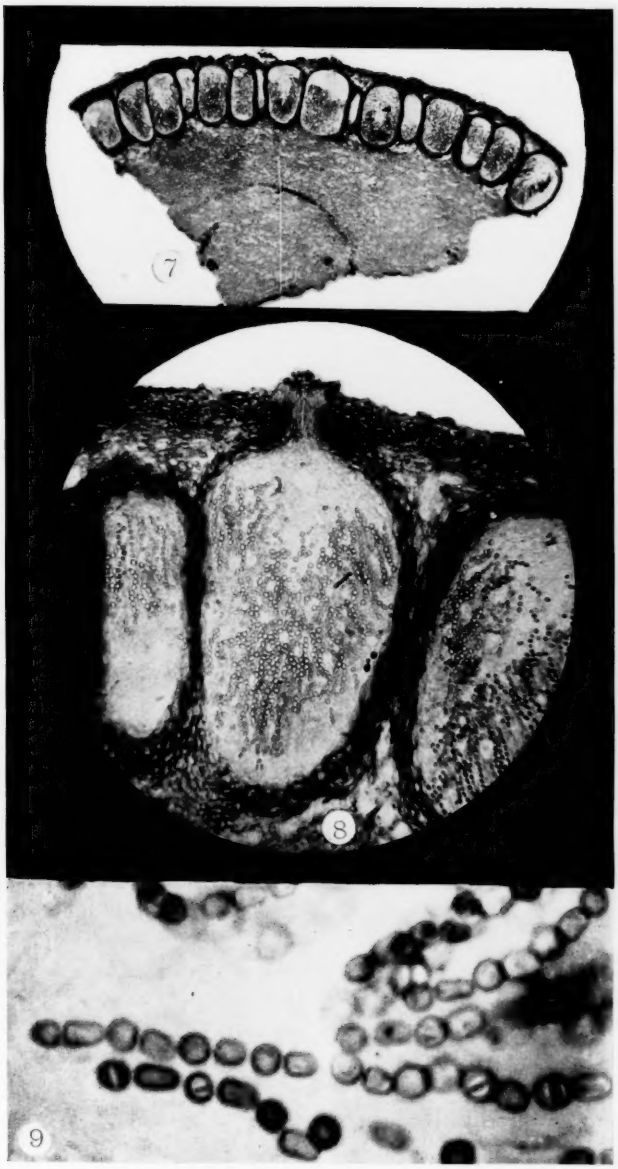
CORNELL UNIVERSITY, ITHACA, N. Y.

[47] Syll. Fung. **11**:355. 1895.

ATKINSON on HYPOCREA



ATKINSON on HYPOCREA



ATKINSON on HYPOCREA

EXPLANATION OF PLATES XIV–XVI.

The photographs and photomicrographs were made by the author, except *fig. 3* of *plate XIV* which was made from a print kindly loaned by Mr. C. G. LLOYD.

PLATE XIV.

FIG. 1. Plants collected at Ithaca on very rotten wood. *a*, Clavaria form; *b*, Spathularia form; *c*, abnormal form; *d*, young individual; real size.

FIG. 2. Pure culture in test tubes, parentage from *a* and *b* of *fig. 1;* real size.

FIG. 3. *Hypocrea Lloydii* Bresadola, from leaf mold; note that one-half of the stem was developed underneath the leaves and leaf mold, which makes the stem long; real size.

PLATE XV.

Photomicrographs from plants collected at Ithaca. In *figs. 4, 5* the plate-holder was 36^{cm} from the object, and in *fig. 6*, the plate-holder was 48^{cm} from the object.

FIG. 4 with Zeiss ocular 4, obj. 16^{mm}.

FIG. 5 with ocular 4, obj. 3^{mm}.

FIG. 6 with ocular 18, obj. 3^{mm}. Note the chain of 16 segments of the eight spores from a single ascus, beginning at apex of series at left, the segments alternate, globose or cuboidal, and oblong.

PLATE XVI.

Photomicrographs from type specimen of *Hypocrea Lloydii* Bresadola. In *figs. 7, 8* the plate-holder was 36^{cm} from the object, and in *fig. 9* the plate-holder was 48^{cm} from the object.

FIG. 7 with ocular 4, obj. 16^{mm}.

FIG. 8 with ocular 4, obj. 3^{mm}.

FIG. 9 with ocular 18, obj. 3^{mm}. Note form of the sixteen segments in the chain of 8 spores from one ascus, apex of series at left.

THE BOGS AND BOG FLORA OF THE HURON RIVER VALLEY.

EDGAR NELSON TRANSEAU.

(WITH SIXTEEN FIGURES)

[*Continued from p. 375.*]

THE BOG AS A HABITAT FOR PLANTS.

WHEN we consider the bog as a habitat for plants, there is at once brought to mind the marked contrast between its characteristics and those of the other plant habitats of its vicinity. In both its atmospheric and edaphic conditions it is unique. The various factors entering into the plant environment will be discussed as physical, chemical, and biotic agents.

A. PHYSICAL FACTORS.—1. *Wind.*—Because of the fact that so large a number of our bogs lie in depressions surrounded by hills, the influence of the wind is somewhat lessened. It is only in the case of the larger basins that its effects become marked. It has been noted by several students of bogs (**41, 5,** p. 37; **59, 47**) that in the region of prevailing westerly winds the greatest development of bog areas and peat deposits occurs on the western sides of lake basins. Where the deposition has taken place in a large lake basin, which is now only partially filled, we commonly find open water occurring toward the eastern side. The peat deposits at Portage, Parks, and West Lakes in the vicinity of Ann Arbor are massed on the western shores, while the eastern margins exhibit an ordinary lake beach. At the bogs north of Delhi, although nine-tenths of the original basin has been filled, the two small lakes are near the eastern margin. The facts noted in this region all favor the idea of the bog plants being unable to gain a foothold on the eastern side in the presence of wave action. The shoreward thrust of the ice is of importance at times in this connection.

Farther north in Michigan the wind frequently shows its extreme effect in these bog areas in the presence of "windfalls." Owing to the character of the substratum, such areas are more readily affected

than the forests of mineral soils. These phenomena have not been observed in any of the bogs in this vicinity.

The same statement holds for the presence of loose floating bogs which are driven about on lakes by winds (**35**).

2. *Temperature.*—In its temperature relations both the topography and the character of the substratum combine to influence the bog habitat. It has long been noted by agricultural writers that reclaimed bog areas are particularly subject to late frosts in the spring. One of the causes of this peculiarity lies in the fact that on clear and quiet nights the cooled air overlying elevations drains into the depressions (**11**). Some recent observations made by SEELEY (**45**) near Chicago show how effective such atmospheric drainage may be even in districts whose range of elevations amounts to but 15 feet (4.5^{m}). He found that the hilltop averaged, on the night of the observations, 2.5° F. (1.4° C.) higher than that of the depression while a thermometer placed 30 feet (9^{m}) above the hilltop averaged 8.8° F. (5° C.) above that of the "swale." On comparing the temperatures of atmospherically undrained and drained depressions with that of the hilltop, he found that the hilltop temperature was 36.3° F. when that of the drained depression was 36° F. and that of undrained 31.8° F. Here is a particular instance in which frost occurred in the undrained depression, but not in the other situations. On quiet nights low grounds in general are subject to lower temperatures than the adjoining highlands, and it is probable that these effects are more pronounced in the case of undrained depressions.

A second factor in the production of low temperatures in bogs is found in the nature of the substratum. In the spring the ice which has formed beneath the cassandra and tamarack areas melts with extreme slowness, when once the surface of the soil has been reached. This is explained by the low conductivity of the loose, partially decayed, vegetable covering, and by the shading of the plants above. For example, at First Sister Lake, in 1904, the ice had disappeared from the water surface on April 10. On April 17, with an air temperature of 10° C., the temperature of the substratum in the bog sedge zone averaged 10° C., in the Cassandra zone 6° C., in the tamarack zone 3° C., and the area of willows and sedges 8° C. Ice was found at several points among the tamaracks, an inch below the

surface. The sedge zone was covered with 1 to 3 inches (25–75^{mm}) of dark colored water. The other soils were wet, but their loose texture was effective in preventing a rise of temperature.

It follows that of the various situations in bog areas those most liable to extreme low temperatures in the spring are in the cassandra and tamarack zone. Since their maximum temperatures are considerably below those of neighboring areas, on quiet nights the plants there are but little protected by radiation from the soil as compared with plants of other situations.

In the following table it is shown that the soil temperatures of the several plant societies formed about a bog are different, and that each society has a characteristic temperature range. The records were made at First Sister Lake. The temperatures, given in °C, are averages of readings made in the second inch (25^{mm}) below the surface. The "willow-sedge" conditions correspond to those of the ordinary swamp. The "maple-poplar" is an area of these trees on the peat substratum. The "upland" is a sandy, sod-covered area 3 feet (0.9^{m}) above the surface of the bog. The temperatures for the most part were taken on clear afternoons about 3 P. M. when the differences are at their maxima.

Date →	April 4	April 12	April 17	April 25	April 29	May 3	May 6	May 16	May 21	May 27	June 6	June 15
Air temperature	10.5	2.0	10.0	8.5	18.0	24.0	27.0	15.0	26.0	21.0	26.0	26.0
Upland	11.0	7.0	10.0	10.0	17.0	20.0	23.0	16.0	20.5	21.5	25.5	26.0
Willow-sedge	7.0	8.0	8.0	9.0	14.5	17.7	19.5	15.0	20.0	22.0	22.0	20.5
Cassandra	1.5	2.0	6.0	7.5	11.0	14.7	15.5	13.0	16.5	19.0	20.0	19.5
Tamarack	0.0	0.0	3.0	4.5	9.9	11.7	15.0	10.6	15.0	17.0	18.0	18.0
Bog-sedge	9.0	8.0	10.0	9.0	18.0	19.0	22.0	16.0	20.0	23.0	24.0	23.0
Maple-poplar	7.0	8.0	8.0	8.0	15.0	18.0	19.0	15.0	16.0	15.0	17.0	16.5

In the accompanying diagram (*fig.* 5) it will be seen that the upland, bog-sedge, and willow-sedge soil temperatures do not deviate widely from those of the air, while the temperatures of the cassandra and tamarack areas range considerably lower. The high temperature of the bog-sedge zone finds its explanation in that the brown bog water overlying its surface absorbs heat. I have tested this point many times in various bogs and have always found such bog water to have a higher temperature than that of the saturated substratum adjoining it. In its ability to absorb heat rays it approaches that of drained sand. Its range, however, is much less and it retains its

heat for a longer time. Consequently on cloudy days and following a sudden lowering of the air temperature, the surface bog-water temperature stands above that of the drained and undrained soil.

When we compare the effects of loss of heat from a free water surface and a saturated humus soil surface due to evaporation, there

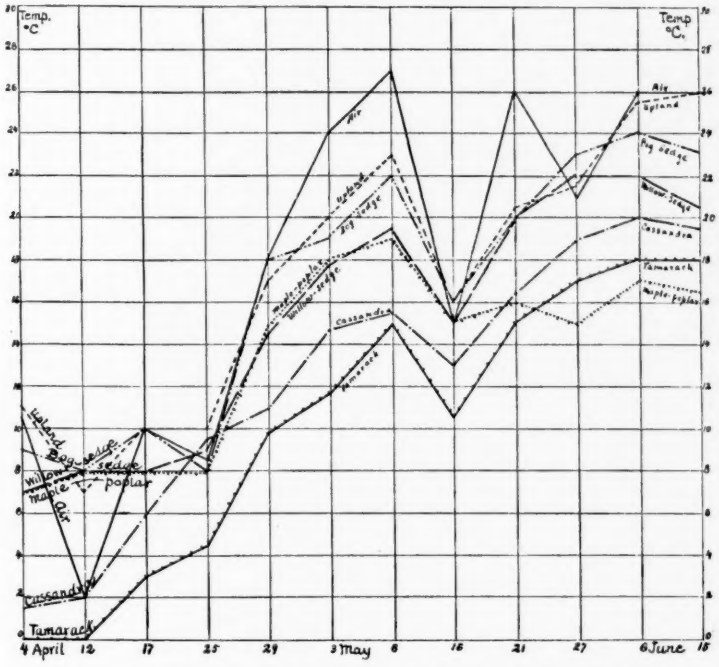


FIG. 5.—Diagram showing temperatures of the air and the substrata in the several plant societies.

is a marked difference due to their specific heat. The humus will be cooled more rapidly by the evaporation of a given amount of water. Where so large an evaporating surface is exposed to the air as in the case of a sphagnum-covered area the loss of heat by this process is most effective in preventing the penetration of heat below the surface.

In the case of drained soils, the most effective agent in raising

the temperature of the subsoil is that of percolating water which has been warmed at the surface of the soil. Because of the high water-table and the stagnant condition of the underground water in bog areas, this source of heat is relatively unimportant.

The effects of these factors, resulting in low soil temperatures, are far-reaching. As compared with well-drained soils, chemical action is retarded, the rate of diffusion, solution, and osmosis is greatly reduced, and the conditions for the existence of soil bacteria made unfavorable. Plants which can successfully compete for the occupancy of such areas must be able to withstand low temperatures and late frosts. The difference between the temperature of the air and that of the substratum favors plants having a low transpiration ratio.

However, in so far as the region of southern Michigan is concerned, the temperatures prevailing in bog areas do not seem to be adequate to account for the presence of the bog plants or their xerophilous structures. It is to be noted that with the leafing-out of the trees, about May 27, the temperature of the maple-poplar substratum falls below that of the tamarack. But that the soil temperature is one of the factors entering into the problem of competition between species there can be little doubt. It is probable also that in the region of optimum conditions for bog plants the conditions which occur here only in the spring are prolonged through the summer. That is, the difference between air and substratum temperatures is more marked, and is a powerful factor in the selection of plants for bog areas and in the production of xerophilous structures.

3. *Texture.*—This property of the substratum has already been referred to in connection with the genetic changes in peat. The sedge zone is developed upon a raft of interwoven rhizomes and roots. It is a coarse meshwork; but since it lies at or below the surface of the water, its texture is of slight importance except as a means of mechanical support. As the bog develops, the admixture of moss and shrub débris brings about the formation of a rather compact peat, overlaid by a stratum of loose material. In some cases, as at Delhi and Oxford, 45 miles (72^{km}) northeast of Ann Arbor, the living sphagnum makes up the bulk of this loose covering. Usually the water level lies just beneath it. As a consequence, this covering becomes the

principal seat of root activity. The small, fibrous roots of cassandra, andromeda, and the cranberry penetrate it in all directions, and it is from the water which is held among this moss and débris that they derive their water and mineral salts.

The substratum beneath the tamaracks is also covered by a loose litter of leaves and twigs, with more or less moss. Depending upon the height above the ground water level, this surface layer is of greater or less thickness. In it occur the wide-spreading roots of the tamarack. During summer and autumn it furnishes admirable conditions for the growth of fungi, and it is penetrated everywhere by their mycelia.

When bog land is cleared, the decomposition of the surface layers is very rapid, owing to exposure to sunlight and higher temperatures. If the water-table is maintained near the surface, sedges and willows develop as the covering. The annual increment of plant material is often decreased, and in place of the fibrous and porous substratum there is produced a black, close-textured, and plastic muck.

If ditching and draining are added to clearing, the summer drought dries the surface layer so thoroughly that it often becomes the habitat for many dry-ground weeds. Decay progresses in moist weather under the influences of the higher temperatures resulting from increased absorption of the sun's energy by the dark colored soil.

4. *Mechanical properties.*—Bog soils in general do not afford as good a foothold for the development of tree species as do the mineral soils. On account of the high water-table, the roots of the plants are not able to penetrate to a depth of more than a few inches. The roots of the tamaracks spread out in all directions from a flat trunk base, and upon the size and strength of these horizontal roots depends the tree's ability to withstand mechanical strains tending to displace it. There can be no doubt but that, in the thick groves in which the tamarack occurs, the interweaving of the roots from adjacent trees becomes of mutual advantage, in so far as the roots function as holdfast organs.

5. *Diffusion properties.*—A most important soil property relates to the diffusion of mineral salts. This becomes of especial significance in saturated stagnant substrata. The mineral salts must be distributed to the roots mainly by diffusion, for lateral drainage

and percolation are at a minimum. It is well known that when salt solutions are passed through soil, much of the salt is retained by absorption. The relative amount is greatly increased in the case of humous bodies. BLANCK (**4**) has further found that the diffusion of water in humus soils is decreased by the presence of acid humus compounds, and that this may be corrected by the addition of a neutralizing agent, such as lime. All analyses of peat show how little of this mineral matter has been derived from the adjacent soils. It is only in the case of samples taken from the bottom or edge of a bog that the mineral salts cannot be accounted for by the amount derived from the decay of the plant material, and that obtained from the atmosphere.

6. *Water-capacity.*—The high water-capacity of peat has already been noted. In relation to plant growth, it is detrimental in that it prevents proper aeration of the substratum (**39,** p. 346). So far as the diffusion of gases is concerned, such substrata are less favorable than a free water surface. King (**29,** p. 161), in speaking of sand and clay soils whose water-capacity is only 17.5 to 32.2 per cent. by weight, says that 30 to 40 per cent. of their saturation amounts must drain away before the soil can contain air enough to maintain the respiration of roots and germinating seeds. As compared with a free water surface, saturated humus cannot admit oxygen as freely, owing to the large part of the surface actually occupied by the humus (**29,** p. 239). In a chemical way it is still more effective, as will be noted later.

7. *Osmotic pressure.*—The osmotic pressure of bog waters has been found to be about the same as that of ordinary lakes and rivers.[3] They are approximately equivalent to a 0.1 to 0.5 per cent. normal Knop's solution. They indicate quite certainly that bog plants do not owe their distribution and their peculiar structures to a high osmotic pressure of the bog water.

[3] Four samples of bog water from this vicinity were tested by Dr. B. E. LIVINGSTON, of the University of Chicago, and found to have the following pressures in millimeters of mercury at 25° C.:

First Sister Lake, Sample A	50.0742
First Sister Lake, Sample B	40.0593
West Lake, Sample A	100.1484
West Lake, Sample B	150.2226
Lake Michigan water	100.1484

See **33.**

B. CHEMICAL FACTORS.—1. *Ground water.*—The ground water of the Huron basin derives its mineral constituents from the glacial drift. The following analyses show the character of the solution. Quantities are expressed in parts per million (**31**).

	$CaCO_3$	$CaSO_4$	Fe_2O_3	$MgCO_3$	K_2SO_4	SiO_2	NaCl	Na_2CO_3	Na_2SO_4	Organic and volatile	Total mineral matter
Ann Arbor, University well.	178.00	.....	3.99	60.58	6.78	7.30	4.48	1.52	5.07	3.85	267.72
Ann Arbor, spring.....	228.00	.....	6.43	89.36	5.31	9.20	4.88	0.42	9.71	25.00	353.31
Ypsilanti, water works....	289.00	39.00	21.00	100.00	.....	14.00	35.00	.....	.....	71.00	498.00
Ypsilanti, well.....	156.00	223.00	Tr.	109.00	.....	18.00	62.00	17.00	.....	14.00	585.00
Ann Arbor, creek.....	128.00	99.00	Tr.	83.00	.....	25.00	15.00 (NaK)	25.00 (NaK)	.....	14.00	375.00

It is to be noted that they are all high in calcium and magnesium content, and under favorable drainage conditions contain sufficient minerals for plant growth. The ground water is of especial importance in the early stages of bog development, when the sedge and aquatic vegetation is dominant. With the further development of the sedge zone and the formation of a thick peat deposit, its relation to the vegetation becomes of less moment. There is a notable difference between the total mineral content of bog water and that of the soil waters adjoining. In the above table the total mineral content of the ground water varies from 267.7 to 585 parts per million. In three analyses of the bog water at the First Sister Lake I found the total mineral content to vary from 89.9 to 219 parts per million, the highest figure being that for the sample obtained near the margin of the tamaracks, *i. e.*, nearest the mineral soil.

The absence of sphagnum from certain bogs has been explained by the presence of calcium salts (**15,** p. 23, **16**). In order to test this point, I have cultivated the species found in this vicinity in tap water and in a saturated solution of $CaCO_3$, and have found no detrimental effects due to calcium. The experiments will be discussed later. I further found that the ash of sphagnum growing at First Sister Lake contained 18 per cent. of CaO. It would seem, therefore, that, in so far as this vicinity is concerned, the presence of calcareous waters will not explain the absence of species of sphagnum.

2. *Acidity.*—Much stress has been laid by various authors, following SCHIMPER (**44**, pp. 6, 18, 124), upon the acidity of the bog water as a factor in the bog habitat. In order to get a quantitative statement of the acidity for the bogs of this vicinity, a number of 50^{cc} samples have been titrated with an $n/100$ solution of potassium hydrate Phenolphthalein was used as an indicator. The results show an acidity varying from .00015 to .00258 normal acid.[4] The lowest values are found in the areas occupied by bog sedges and by swamp plants, and they are practically the same. The areas occupied by cassandra and sphagnum have a somewhat greater acidity. The highest percentages are found beneath the tamaracks. The explanation of these variations in acidity is suggested by the tests, made from time to time, of the water in my experimental cultures. I found that the acidity of the water increased slowly in the undrained peat substratum cultures (see experiments). The increase was small in the case of the warm cultures, but quite notable in the case of the cold undrained substratum. On exposure to air in the water cultures, and in bottles, the acidity very slowly decreased, the decrease being greatest in the case of the water which was kept warm. This is probably due to increased oxidation. These relative amounts of acid, it will be seen, may be correlated with the temperatures in the several plant societies of the bog, the lowest temperatures corresponding to the highest percentages of acid. This suggests the probability that the acidity of the bog substratum increases farther north.

On allowing open dishes of bog water to stand for some time, I found that the evaporation was not sufficient to raise the acidity of the water, oxidation apparently being more rapid than concentration of the solution.

There is no apparent relation between color and acidity, although the lightest colored solutions usually show but slight acidity. This seems to indicate that only a part of the color is produced by free humus acids, the remainder by humates of the alkalies.

[4] Following are the determinations expressed in fractions of a normal acid solution:
First Sister Lake: sedge zone, .00066, .00094; cassandra zone, .00152, .00119; tamarack area, .00165, .00179, .00227, .00258; willow-sedge area, .00089, .00072.
Chelsea: ditches, .00086, .00015, .00043, .00019, and .00029.
Delhi: tamarack area, .00146, cassandra zone, .00117.
Oxford: cassandra zone, .00094.

The effect of acidity upon cultivated plants has been investigated in this country especially at the Rhode Island Agricultural Experiment Station, under the direction of Professor H. J. WHEELER. The experiments have been conducted upon "acid upland soils" (**60**), and numerous reports have been published. These experiments involved a great variety of plants and were carried on under natural field conditions. The areas planted for comparison had their acidity neutralized by the addition of $CaCO_3$. The plants which were favored by the liming include the orange quince, black Tartarian cherry, Japan plum, *Tilia americana*, *Ulmus americana*, rhubarb, Australian salt-bush, hemp, barley, oats, onions, *Anthoxanthum odoratum*, *Poa pratensis*, *Festuca ovina*, *Holcus lanatus*, *Festuca elatior*, *Alopecurus pratensis*, etc. Plants which appear to be adapted to the acid soil conditions include cranberry, blackberry, raspberry, sheep sorrel, cow-pea, flax, corn, lupine, and soja bean. It would appear, then, that the acidity of the soil solution is unfavorable for the growth of some plants, and that it is a factor in the selection of species for acid soil conditions.

3. *Food material.*—As to the presence of plant food materials in the bog soil there is an agreement among all the analyses that have been made.[5] The soils are unusually rich in nitrogenous materials, some analyses showing three times as much as good upland soils. But in the slow decay of the vegetable matter the nitrogen remains bound up in organic compounds and is unavailable for the growing plants. This is confirmed by experimental tests in which nitrogen was directly applied, and by tests in which the conditions were modified so as to permit the action of nitrifying bacteria. In such cases crops were produced when the untreated humus produced none.

Under natural conditions the growth of the nitrifying bacteria in bog soils is almost impossible. Three factors work against their activity: (1) the acidity of the soil solution; (2) the lack of oxygen due to high water content; (3) the lower temperature. It has been found that the optimum temperature for these bacteria is 98° F. (36.6° C.), and that their activity is very slight at 50° F. (10° C.)

[5] Analyses of Wisconsin soils. Ann. Rept. Wis. Agric. Exper. Sta. **13**: 304. 1896. See also **27**, p. 12; **23**; **22**, p. 276; **30**; **48**, p. 234; **12**, p. 39; **14**.

(**3**). Furthermore, it has been shown that when soil rich in nitrogen is saturated with water so as to exclude free oxygen, denitrification takes place and nitrogen gas is set free (**29**, p. 115).

The phosphoric acid content is comparable with that of the best soils, and it is at least partially in a condition for plant use.

The potassium content is very low. Analyses and the results of agricultural experiments show that in order to produce crops this substance must be added, and preferably in an alkaline form. Inquiry among the owners of onion marshes in this vicinity confirms the need for potassium in local bog soils.

The amount of calcium present is reported as equal to that of the best upland soils. But it is probable that as it exists under natural conditions in bogs it is bound up largely in insoluble humates. Under the influence of oxidizing processes it would become available to the plants at the surface.

When we consider the conditions under which the various plant societies in our bogs exist and their competition with one another, there can be little doubt but that the substratum varies in each case as to its chemical composition. That the societies may be classified on a physiographic basis is certain, but how to determine the chemical factors accompanying each physiographic change is an unsolved problem. The ordinary methods of analysis give us the minerals present, but tell us little about their form and availability for plant assimilation. The colorimetric methods for determining the quantity of mineral salts present in bog water are mostly open to objection. The ease with which the humous bodies of the bog water are decomposed render their quantitative estimation by present methods of little value. Yet it seems probable that work upon the chemistry of humus and humous compounds must result in data valuable alike to the ecologist, the forester, and the agriculturist.

C. BIOTIC FACTORS.—The interrelations of the bog species will be discussed in connection with their other ecological characters. It will be sufficient to mention here that they are with a few exceptions light-demanding forms. Consequently, size and ability to produce shade are the important factors in their competition with one another.

A second element enters into this problem of the struggle between

species near the borders of the area of geographic distribution of the bog plants, viz., climate. The bog plants of this vicinity come into conflict with species whose range is either more nearly continental or more southern. That the climatic and edaphic conditions of this region are at present unfavorable to the successful competition of the bog species with swamp species is evidenced wherever the bog conditions have been disturbed. That the reverse is the rule in eastern Canada has been shown by GANONG (**18,** p. 178). The tenacity with which species, whose multiplication is principally accomplished by vegetative means, hold an area under complete control is apparent to any who have studied the vegetation of lake shores. It is just as strongly marked in the case of the herbaceous and shrubby bog vegetation. When we examine the chemical and physical data, now at hand, concerning the soils occupied by bog and swamp plants respectively, the conclusion must be that they are wholly inadequate to account for the difference in vegetation. The forester lays stress upon the fact that trees cannot gain a foothold on areas now covered with a grass turf because of the difficulty of the seedlings getting started. The bog societies form an equally compact plant growth, and their preservation in this region would seem to be dependent upon analogous factors.

III. The bog-plant societies.

The following descriptions of local bog areas occurring in the Huron valley aim not only to present lists of plants found in this vicinity, but to show their natural associations. The order in which the areas are described corresponds to the relative amount of filling which has occurred in the several basins. To a certain extent this order is genetic, yet there can be little doubt but that many arctic plants which were concerned in the pioneer stages of our mature bogs are now extinct. If we accept the areas at West and First Sister Lakes as representing bogs in youth, maturity may be illustrated by the original vegetation of the bog on Carpenter's road. The Chelsea area defines that stage beyond the climax, when the conditions inaugurated by cutting, firing, and ditching have destroyed the original tamarack forest, and in its place has come a rude mixture of bog relicts and arborescent weeds.

WEST LAKE.

This lake, situated three miles north of Chelsea (Sec. 30, Dexter Tp.), is also known locally as Johnson's Lake. In area it is slightly more than a fourth of a square mile (65 hectares). The margin of the lake originally extended a half mile (0.8^{km}) farther west and southwest. This part is now occupied by a partially floating bog. The north, south, and east shores are sandy and low. Patches of bulrushes and water-lilies occur here and there over the lake and show its generally shallow character. Toward the east there is a narrow swampy outlet by which its water after a long and circuitous route reaches the Huron River. There are no streams tributary to the lake. The basin lies near the southeastern margin of the interlobate moraine, and is bounded on the north and south by hills 60 to 80 feet (18–24^{m}) in height. Not all of the original extension to the southwest has been filled by peat; two small areas of open water still remain.

The shores, with the exception of the western side, support a vegetation similar to that of many lakes in this region. Three societies of plants may be distinguished.

Aquatics.—The most abundant plants are Scirpus lacustris, Castalia tuberosa, and Sagittaria rigida. These occur not only along shore, but in shallow water throughout the lake. Associated with these are Naias flexilis, Brasenia purpurea, Potamogeton heterophyllus, Chara (sp.), Spirodela polyrhiza, Vallisneria spiralis, Scirpus americanus, and Decodon verticillatus.

Sedge-grass society.—Very near the north, south, and east shores occur a great number of species of grass-like plants. Their associations vary greatly at different parts of the shore line. The dominant forms are Carex filiformis, Panicularia nervata, Eleocharis palustris, Carex teretiuscula, C. Muskingumensis, Dulichium arundinaceum, Panicularia Canadensis, Dryopteris Thelypteris, and Scutellaria galericulata. Among the species of secondary importance are Onoclea sensibilis, Carex riparia, C. stipata, C. hystricina, C. interior, Spartina cynosuroides, Typha latifolia, Iris versicolor, Lobelia Kalmii, Comarum palustre, Lycopus americanus, and Eupatorium maculatum. Closely associated with these plants are the seedlings of the shrubs and trees which make up the next society.

Willow-maple society.—The shrub and tree border is composed,

for the most part, of Salix Bebbiana, S. discolor, S. sericea, Cornus candidissima, Acer rubrum, and Ulmus americana. Beside the many plants of the sedge-grass society which remain as relicts, the accessory species include Rosa Carolina, Impatiens biflora, Sambucus pubens, Spiraea salicifolia, Prunus serotina, Quercus alba, Q. velutina, and Opulaster opulifolius. These trees grade into the forests of the upland and establish a natural order of succession.

An interesting comparison is afforded when we note the species dominant along the western or bog margin. Here the outer zone of aquatics is made up of the same species, but this substratum is a floating raft constructed by the plants themselves. Without again enumerating the species, we pass to the society which closely follows their development.

Bog-sedge and shrub society.—This society forms a very complex growth, averaging 50 feet (15 m) in width. On the lakeward side are the aquatics; on the other, the growth of tamaracks. The sedges and shrubs are not separable, as in many other localities. Carex filiformis is by far the most important plant in the society. Its vigorous production of rhizomes and roots especially fit it for the position which it occupies. Certain other plants are locally abundant and of great consequence. These include Dryopteris thelypteris, Menyanthes trifoliata, Eleocharis palustris, Comarum palustre, Sagittaria latifolia, Eriophorum polystachyon, Carex teretiuscula, Typha latifolia, Salix myrtilloides, S. candida, Betula glandulosa,[6] Oxycoccus macrocarpus, and Andromeda polifolia. As accessory species may be mentioned Salix discolor, S. Bebbiana, Cicuta bulbifera, Cardamine pratensis, Chamaedaphne calyculata, Campanula aparinoides, Rumex Britannica, Epilobium adenocaulon, Asclepias incarnata, Pogonia ophioglossoides, Blephariglottis blephariglottis, Limodorum tuberosum, Marchantia polymorpha, Aulacomnium palustre, Sarracenia purpurea, Drosera rotundifolia, Boehmeria cylindrica, Carex comosa, C. hystricina, Cornus stolonifera, Parnassia caroliniana, Viola blanda, and Penthorum sedoides. Here and there occur young tamaracks which by their growth inaugurate the next society.

Tamarack society.—As development proceeds, the shrubs and

[6] The form found here and at Delhi corresponds more closely to this species than to *B. pumila*, but its characters are intermediate.

herbs gradually are superseded by a growth of Larix. This society has been much disturbed by lumbering, and a large part of the original area has been cleared. But there is good evidence to show that the part of the basin filled with peat formerly supported a dense covering of tamaracks. Where best developed and least disturbed, it shows an undergrowth of Vaccinium corymbosum, Aronia nigra etc. As the other species are practically the same as at the lake to be described next, they need not be enumerated here. In contrast with most of the areas studied, the almost complete absence of sphagnum is worthy of note. It is also important that the absence of any gradation between the forest societies of the upland and of the bog be kept in mind.

On this lake, then, there are two divergent series of plant societies. Starting with practically the same species, the one series leads us on mineral soil through willows, maples, and elms to the oaks of the surrounding forests; the other, owing to the development of a floating substratum, involves a very different set of shrubs and ends with the tamarack. The former series therefore more closely approximates the climatic type, while the latter is dependent upon edaphic factors.

FIRST SISTER LAKE.

This lake and its accompanying bog are located three miles west of Ann Arbor in a glacial drainage valley. Its origin is probably connected with the melting of a mass of stagnant ice after the abandonment of the valley by glacial drainage. The surrounding and underlying soil is a sandy gravel. At least a part of the western side presents an original tamarack bog vegetation, and it is particularly interesting in showing the results of competition between bog plants and those of other habitats (*fig. 6*). The vegetation in general presents a different phase of the bog societies, as compared with West Lake. Especially to be noted are the dominance of cassandra and sphagnum in the shrub zone, the absence of cattails and swamp loosestrife as important members of the outer margin. The tamarack zone is also raised somewhat more above the water level.

Aquatics.—With the exception of the shallow-water forms, the lake is almost free of higher vegetation. Potamogeton lucens and P. zosteraefolius occur sparingly. About the margin, however,

Nymphaea advena is of great importance. It forms an almost continuous zone 10 to 25 feet (3–7.5 m) in width. Patches of Castalia tuberosa and Brasenia purpurea occur. This arrangement in groups seems to be connected with their rapid multiplication by rhizomes. Typha latifolia occurs in a small area at the north end of the lake. Ceratophyllum demersum and Naias flexilis occur as secondary species.

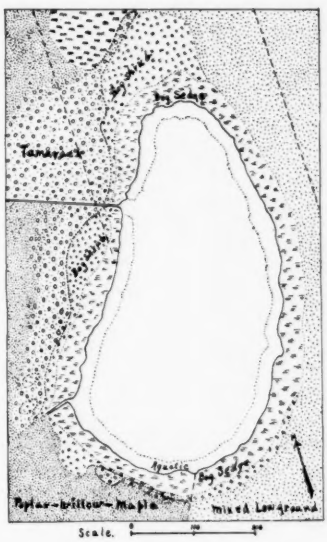


FIG. 6.—First Sister Lake.

Bog-sedge society.—Carex filiformis, C. oligosperma, Eleocharis palustris glaucescens, and Eriophorum polystachyon are the primary factors in the formation of this zone. Carex riparia has gained a foothold at the north end of the lake, where muskrats have been active in destroying the original sedge zone. Dryopteris thelypteris, Onoclea sensibilis, Juncus effusus, J. canadensis, Comarum palustre, Salix myrtilloides, Dulichium arundinaceum, Equisetum fluviatile, Bidens trichosperma tenuiloba, Menyanthes trifoliata, Viola blanda, and Eriophorum virginicum occur as accessory plants. The great majority of these plants aid in the construction of the substratum by their roots and rootstocks.

Here and there among the sedges occur the forerunners of the shrub society. Among the very first to gain a foothold are the sphagnums. These build small tufts of great compactness, and gradually overcome the sedges. The rootstocks of the cassandra also send up shoots and prepare the way for another vegetation form. Oxycoccus macrocarpus and O. Oxycoccus both occur at intervals in this zone.

Cassandra-sphagnum society.—Beyond the sedge zone the vegetation is no longer arranged zonally. Conditions have been so much

disturbed that on the western side the area of cassandra-sphagnum dominance is very irregular. On the eastern side this plant society is in the last stage of its existence. The intimate association of Chamaedaphne calyculata, Sphagnum cymbifolium, S. subsecundum, and S. recurvum is well illustrated here. The plants occupy the whole of the territory where they flourish. The other species are decidedly secondary. It is to be further noted that in the competition with the sedge species these plants actually override them, and only an occasional Eriophorum virginicum survives. The water-conserving properties of the sphagnum are too well known to need description here. But the mutual advantage of the cassandra-sphagnum combination is worthy especial note. The former by its numerous branches furnishes a framework which aids in the upbuilding of the moss and in shading. The sphagnum, on the other hand, furnishes a moist cover in which the conditions for the shrub are most favorable.

The accessory species include the moss, Aulacomnium palustre; the herbs, Drosera rotundifolia, Arethusa bulbosa, Habenaria lacera, Sarracenia purpurea, Pogonia ophioglossoides, Limodorum tuberosum, Viola blanda, Osmunda regalis, Campanula aparinoides, Scutellaria galericulata; and the shrubs, Andromeda polifolia, Betula pumila, Oxycoccus macrocarpus, O. Oxycoccus, Aronia nigra, and Ilicioides mucronata.

Tamarack society.—Among the cassandra occur many young tamaracks, and these by their development come to overshade the shrubs and form the tree society of the bog. The dead remnants of the cassandra mounds make up a large part of the floor beneath them. The species of secondary importance are Ilicioides mucronata, Aronia nigra, Chamaedaphne calyculata, Osmunda cinnamomea, O. regalis, Dryopteris spinulosa intermedia, D. cristata, Polytrichum juniperinum, Plagiothecium denticulatum, Thuidium recognitum, Aulacomnium palustre, Marchantia polymorpha, Sphagnum cymbifolium, Boletinus porosus, and Thelephora intybacea.

The tamarack zone has been much disturbed by clearing and burning. At the present time a large part of the area on the southwest side is dominated by other tree species. Some of the plants of the clearing have spread into the pure tamarack growth.

Poplar-willow-maple society.—Where the original conditions have been disturbed and a second growth allowed to come in, Populus tremuloides, Salix sericea, Salix discolor, and Acer rubrum have obtained dominance. Where groups of the more mature poplars occur there is scarcely any undergrowth. Elsewhere the following plants occur: Ilicioides mucronata, Salix Bebbiana, Sambucus pubens, Amelanchier oligocarpa, Aronia nigra, Rubus nigrobaccus, Cornus stolonifera, and Rubus strigosus. These form a dense mixed association, with but slight reference to substratum conditions. The smaller species present are Adicea pumila, Osmunda cinnamomea, Rosa Carolina, Onoclea sensibilis, Epilobium adenocaulon, Spiraea salicifolia, Dryopteris thelypteris, Verbena hastata, Solanum dulcamara, Polygonum sagittatum, Spiraea tomentosa, Geum rivale, Polygonum hydropiperoides, Ribes floridum, Ribes oxyacanthoides, Rumex Britannica, Impatiens biflora, Viola blanda, Osmunda regalis.

On the southeast side of the lake and on the north, conditions have been still more interfered with, and there is now a mixed growth of bog and low-ground plants, which represent stages in the decline of the bog flora and the advent of swamp plants. The tallest forms are willows and clumps of mountain holly. For convenience only, the plants may be enumerated together under the following title:

Mixed low-ground society.—The dominant plants are Salix sericea, S. discolor, Spiraea salicifolia, Poa flava, Solidago serotina, Chamaedaphne calyculata, Oxycoccus macrocarpus, Aster Novae-Angliae, and Rosa Carolina, Epilobium adenocaulon, Aronia nigra, Andromeda polifolia, Rubus strigosus, Dryopteris thelypteris, Scutellaria galericulata, Juncus effusus, Koellia virginiana, Sambucus canadensis, Geum rivale, Osmunda regalis, Scirpus cyperinus, Galium aparine, Homalocenchrus oryzoides, Juncus tenuis, Asclepias incarnata, Salix Bebbiana, Eupatorium perfoliatum, Gentiana Andrewsii, Lycopus virginicus, Osmunda cinnamomea, Cornus stolonifera, Carex riparia, Viola blanda, Sarracenia purpurea, Dryopteris cristata, D. spinulosa intermedia, and Triadenum virginicum also occur.

The last two societies are found upon a black peat substratum which is more thoroughly decayed than in other parts of the bog.

Acidity tests show that the relative acidity is less than in the case of the cassandra-sphagnum and tamarack societies. The soil temperature also runs somewhat higher as noted elsewhere.

The First Sister Lake may be said to be dominated by three well-marked bog and two mixed societies in which bog and swamp species are brought into competition. The result can be foretold with considerable certainty. The bog vegetation will sooner or later be replaced by the swamp species.

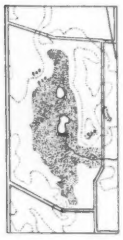


FIG. 7.—Delhi bog and adjacent topography. Scale 1:95,000 ($\frac{3}{4}$ inch = 1 mile).

BOG NORTH OF DELHI.

Two miles north of Delhi occurs an extensive bog which was formerly a mile and a quarter (2 km) long by a half mile wide (0.8 km) at its broadest part (*fig. 7*). The southwestern third has been cleared and is in part under cultivation. The eastern and northern parts have been somewhat interfered with by the cutting of timber, but areas occur which have been but little disturbed by these influences. Near the eastern margin are two small lakes, the last remnants of the larger lake which must have occupied this territory in early postglacial times. The basin is located in a clay moraine of the Erie ice-lobe, and probably owes its origin to unequal deposition by the glacier.

The plant societies found about the southeastern lake will give an idea of the whole vegetation (*fig. 8*).

Aquatic society.—The aquatic vegetation is represented almost wholly by the yellow water-lily, Nymphaea advena. This plant forms a broader zone completely encircling the lake and varying from 5 to 10 feet (1.5–3 m) in width. Accompanying it occur Brasenia purpurea, Ceratophyllum demersum, Lemna minor, and Spirodela polyrhiza.

Typha-cassandra-sphagnum society.—On the floating margin of the bog substratum occurs a zone which partially encircles the lake. Near its outer edge Typha latifolia is the characteristic plant, but in certain places it is wanting or extends the full width of the zone. Chamaedaphne calyculata, Sphagnum cymbifolium, S. subsecundum, S. recurvum, Carex filiformis, Eriophorum polystachyon, and Salix

myrtilloides are the most frequent plants. The accessory species include Carex oligosperma, Menyanthes trifoliata, Comarum palustre, Triadenum virginicum, Osmunda regalis, Onoclea sensibilis, Rumex Britannica, Asclepias incarnata, Viola blanda, Cicuta bulbifera, Galium Aparine, Scutellaria galericulata, Rhus Vernix, Dulichium arundinaceum, Oxycoccus macrocarpus, Hypnum cordifolium, Hypnum Schreberi, Aulacomnium palustre, and Mnium.

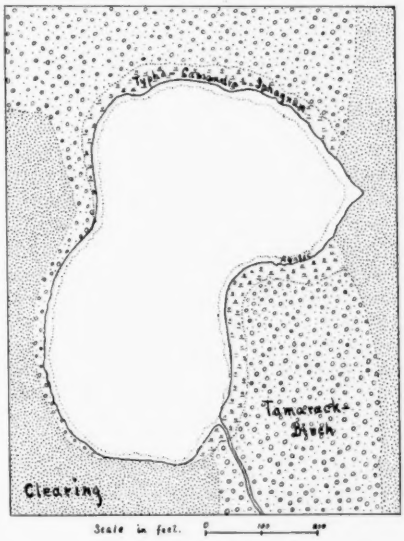


FIG. 8.—Portion of Delhi bog.

Vaccinium-aronia society.—Forming a narrow transition society between the low shrub zone just described and the tree society, occurs a dense line of tall shrubs. The dominant species are Vaccinium corymbosum, Gaylussacia resinosa, Aronia nigra, Ilicioides mucronata, Betula glandulosa, and Prunus serotina. The other species present are Acer rubrum, Sambucus pubens, Osmunda cinnamomea, Salix discolor, S. Bebbiana, Spiraea salicifolia, Ilex verticillata, Rosa Carolina, Sarracenia purpurea, Andromeda polifolia, Calamagrostis canadensis, and Eleocharis palustris glaucescens. These shrubs border the tamaracks and to varying distances extend back among them.

Tamarack-birch society.—Larix laricina and Betula lutea must have made up the great bulk of the original forest which occupied this area. The relative abundance of the latter has probably been increased by the cutting of the tamarack. The next most important tree is Acer rubrum, which occurs scattered throughout, but is especially abundant near the northeast side. Where isolated trees have been removed, the shrubs which occur among the undergrowth have

made a rapid growth. Throughout the forest area are patches in which Aronia nigra, Vaccinium corymbosum, and Ilicioides mucronata stand so thickly as to be almost impenetrable. Where the forest has been but slightly disturbed and the tamaracks are more or less scattered, one finds a deep carpet of sphagnum with slender stems of cassandra, andromeda, and Eriophorum virginicum rising through it. Clusters of Sarracenia purpurea are common. The other plants found in this society are Trientalis americana, Unifolium canadense, Coptis trifolia, Rumex Acetosella, Rubus strigosus, Dryopteris spinulosa intermedia, Osmunda cinnamomea, Viola blanda, Impatiens biflora, Solanum dulcamara, Thelephora intybacea, Polytrichum juniperinum, Sambucus pubens, Agrostis alba, Blephariglottis lacera, Cornus candidissima, and Cicuta maculata.

Clearing society.—Surrounding the forest on the east, south, and west sides is a large area, in part dominated by sedges and grasses, and in part by a typical "slashing." It is impossible to characterize this plant association by any particular species. All that have been thus far mentioned occur in scattered clusters, the proportions and dominant plants varying from one locality to another. The notable facts are that on the east side Carex teretiuscula, C. vulpinoidea, C. riparia, C. filiformis, Scirpus cyperinus, Calamagrostis canadensis, Aster Novae-Angliae, Eupatorium perfoliatum, and Aster junceus have become the most abundant forms. To the west of the lake these plants are present, but the taller shrubs are in control. Salix discolor, Cornus stolonifera, Salix Bebbiana, S. sericea, and many others already mentioned as occurring among the tamaracks are present.

The second lake and the more northerly one is bordered by an exceedingly narrow zone of low-growing plants. The dominant species are Decodon verticillatus and Typha latifolia. Chamaedaphne calyculata, Carex riparia, Panicularia canadensis, and Bromus Kalmii are of secondary importance. The trees come almost to the water's edge. The proportion of red maples among the tamaracks and birches is considerably greater than in the vicinity of the other lake. Otherwise the tree society is essentially the same.

We have illustrated, then, in the bogs at West Lake, First Sister Lake, and Delhi, three stages in the filling of old lake basins. We

have seen that, although there are minor variations in the species present, all of the bogs show a series of bog-sedge, shrub, and conifer societies which are genetically related. In the Delhi bog the filling is almost completed. In the bog about to be described we find this process finished, and what was formerly a ring of bog-sedges surrounding an open lake has become an irregular disk forming the central plant society of the area.

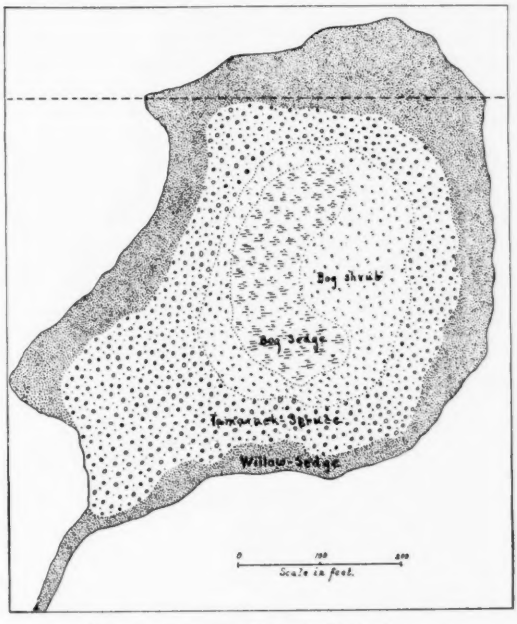


FIG. 9.—Bog near Oxford, Oakland county.

BOG NEAR OXFORD, OAKLAND COUNTY.

Near the northeast corner of Sec. 31, Oxford Tp., there is a bog (*fig. 9*) covering about 4.5 acres (1.8 hectares). Although it lies a few miles beyond the real boundary of the Huron River basin, it is included because it exhibits a flora somewhat different from the other areas, and may be considered as a near approach to the type of bogs occurring farther north. The basin is a depression in the outwash sands and gravels of the interlobate moraine. It is sur-

rounded by hills 25 to 30 feet (7.5–9^{m}) in height above the bog level. During wet weather it has a shallow outlet to the southwest. The land surrounding it has all been cleared and is now under cultivation. As shown by other timber areas in the vicinity, it is probable that the original upland timber was made up in part of Pinus strobus, Quercus coccinea, and Betula papyrifera.

Bog-sedge society.—Toward the center of the bog is a considerable area in which the water level lies just at the surface. The sphagnum is for the most part submerged, and the dominant plants are Carex oligosperma and Scheuchzeria palustris. Occasional plants of the following society are scattered throughout.

Bog-shrub society.—While this zone is characterized by Chamaedaphne calyculata, Sphagnum cymbifolium, S. recurvum, and S. subsecundum, young and dwarfed specimens of the spruce, tamarack, and pine are present in large numbers. The surface formed by the sphagnum is exceedingly rough and marked by hummocks. Among the depressions Eriophorum virginicum, E. vaginatum, Andromeda polifolia, Sarracenia purpurea, and Oxycoccus macrocarpus are abundant.

Tamarack-spruce society.—This society forms a zone completely surrounding the shrub society, and is dominated by trees of Larix laricina and Picea Mariana. Occasional specimens of Pinus Strobus are found, especially toward the southwest corner, where the substratum is somewhat higher than elsewhere. Beneath the trees is an almost impenetrable tangle of shrubs, especially Vaccinium corymbosum and Ilicioides mucronata. The substratum is practically bare of lower vegetation. An occasional mat of Aulacomnium palustre may be found at the tree bases. That this society will come into possession of the central bog area is certainly indicated by the great numbers of young trees among the bog shrubs.

Willow-sedge society.—As usual in the clearing of the adjacent land, the larger trees of the bog margin were also removed, and in their stead has come up a growth of willows. The dominant plants of this zone are Salix sericea, Cornus stolonifera, Spiraea salicifolia, Salix discolor, Carex riparia, and C. stipata. Associated with these plants are Sambucus pubens, Salix nigra, Iris versicolor, Populus monilifera, Dryopteris spinulosa intermedia, Osmunda cinnamomea,

Equisetum limosum, Cornus candidissima, Aronia nigra, Rosa Carolina, Juncus effusus, Calamagrostis canadensis, Rubus strigosus, Ilicioides mucronata, Comarum palustre, Carex filiformis, Panicularia canadensis, and Poa flava. Forming a high border about the tamaracks and spruces are numerous large plants of Vaccinium corymbosum and Ilicioides mucronata.

The very marked difference between the vegetation of the central and marginal parts of the bog are worthy of especial note. The former represents the original vegetation of the bog. The latter illustrates most forcibly that under present conditions a very different set of plants springs up and becomes dominant, in spite of the fact that the true bog plants were near at hand when the clearing occurred. This bog also illustrates that stage in the filling of a depression immediately following the disappearance of the lake.

In other bogs near Oxford, Dasyphora fruticosa and Chiogenes hispidula occur among the shrubby growth.

THE DELHI MUSKEAGS.

In the bog north of Delhi which has already been described occur two areas, somewhat to the west of the lakes, which seem to represent a later stage in the history of a bog than that shown by the lakes. These areas, if they were found in northern Michigan, would be termed "muskeags." They are surrounded by large tamaracks, and small tamaracks occur throughout, the smallest specimens toward the center. If the bog at Oxford were to continue its work of filling until the central society disappeared, we should have a bog area of much the same appearance. The small tamaracks stand far apart, and between them is a most luxuriant growth of cassandra and sphagnum. The hummocks rise between 3 and 4 feet (0.9–1.2^{m}) above the substratum. As one attempts to traverse these areas, he sinks knee-deep in the long, fibrous, peat moss.

The total number of species is very small, and includes, besides those already mentioned, Andromeda polifolia, Sarracenia purpurea, Oxycoccus macrocarpus, and a few specimens of Vaccinium corymbosum.

BOG ON CARPENTER ROAD

This bog is situated in the SW. ¼ Sec. 36, Ann Arbor Tp. Its basin is a small depression in the glacial moraine occupying about

one-tenth of an acre (*fig. 10*). On the south, west, and north sides it is bordered by clay hills which rise 25 to 40 feet (7.5–12^{m}) above the bog level. The vegetation of the hills is dominated by Quercus velutina, Q. alba, and Q. rubra. With these trees occur Hicoria ovata, Hamamelis virginiana, etc.

On the north side the upland has been cleared, and the land is now under cultivation. From time to time tamaracks have been removed from the bog, until at the present time only the central area remains to indicate the original covering. Accompanying the clearing there has grown up about the tamaracks the usual thicket of shrubs and young trees. As elsewhere, the peat is more thoroughly decayed and the substratum level somewhat lower about the margin than toward the center. This fact is of importance in differentiating the willow-sedge society.

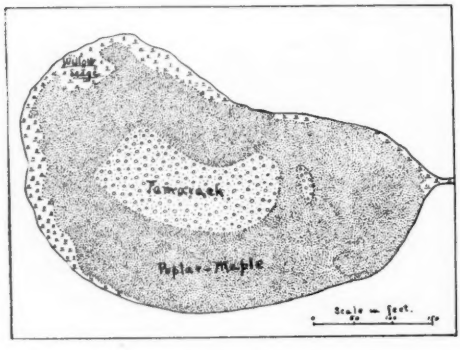


FIG. 10.—Bog on Carpenter road.

Tamarack society.—This society is dominated by the group of rather mature tamaracks. The substratum has the characteristic hummocky surface, marked by large exposed roots, common to such areas. It is overlaid by a loose covering of vegetable matter, made up principally of tamarack needles. The undergrowth is sparse, but most of the bog shrubs and herbs are represented. The more important species are Chamaedaphne calyculata, Sphagnum cymbifolium, S. recurvum, S. subsecundum, Eriophorum virginianum, and Lycopus virginicus. A very noticeable growth about the bases of most of the shrubs is produced by the fungus, Thelephora intybacea. The mycelium in developing its sporophores rises about the stems, frequently to a height of a foot (25^{cm}). From the cylinder thus formed, irregular fan-shaped pilei are developed, which gives

the appearance of an elongated brown rosette about the stem bases. Clitocybe laccata and Boletinus porosus are also abundant in the autumn. The partially decayed stumps bear Peltigera canina. Other species occur in this area, but reach their dominance in the next society.

Poplar-maple society.—Here are brought together the remnant of the bog species, and those more characteristic of swamps and clearings. The trees are mainly Populus tremuloides, with a scattering of Acer rubrum. Elm seedlings occur. The shrubby plants, however, make up the bulk of the vegetation. Ilicioides mucronata, Ilex verticillata, Aronia nigra, and Vaccinium corymbosum have almost complete possession, and are struggling with one another for space. All these forms send up stems from the underground parts, so that among them the struggle is largely a mechanical one. However, where the red maple overtops them, the factor of shade enters, and the black choke-cherry and high-bush blueberry are the most tolerant. The mountain holly and black alder prevail elsewhere. The next most important plants are the willows, Salix sericea and S. discolor. Mixed with these are Cornus candidissima, Rubus nigrobaccus, Rosa Carolina, Cornus stolonifera, Spiraea salicifolia, and Rubus strigosus.

Willow-sedge society.—The area dominated by these plants is covered with water in the spring and during moist weather. Although this society is fast being crowded out by the next preceding, it is probable that only a small part of that area was ever occupied by these plants. These plants require a more moist substratum. The dominant species are Salix sericea, Carex riparia, C. stipata, Cornus stolonifera, and Osmunda cinnamomea. In the case of the cinnamon fern found in this bog there is a remarkable development of aerial roots. They are about an inch long and extend outward from the thick rootstock in all directions, forming a dense covering. The roots are thickly covered with root-hairs which have been persistent at least through one winter. The root-hairs are large and brown in color. The appearance of these rootstocks, as a whole, is very suggestive of certain tropical tree ferns. The other species present are Ranunculus abortivus, Polygonum sagittatum, Cicuta bulbifera, Prunella vulgaris, Rubus americanus, Rhus Vernix, Solanum dulca-

mara, Impatiens biflora, Eupatorium perfoliatum, Calamagrostis canadensis, Dryopteris thelypteris, D. spinulosa intermedia, Doellingeria umbellata, Lactuca spicata, Coptis trifolia, Boehmeria cylindrica, Onoclea sensibilis, Marchantia polymorpha, and Rosa Carolina.

The further development of these societies under present conditions will bring about a complete change. There can be no doubt that the poplars and red maples are the coming trees, with elm a close third. When these have become sufficiently large and numerous to overshade the shrubs, the latter will be killed out, and we shall have in their place the maple-elm forest common to the low grounds. The shrubs, however, are capable of persisting for a great length of time, because of the difficulty of tree seedlings obtaining a start beneath them.

THE CHELSEA BOG.

Of the bogs which have been subjected to clearing, burning, and ditching, by far the most interesting in this region is located just to the southeast of the town of Chelsea. It covers an area of about 50 acres (20 hectares), and the peat is reported to be 40 feet (12^{m}) thick at the deepest places. The divisions into societies, as indicated on the map (*fig. 11*), are based on the most general characters of the vegetation. There are gradations between all of the societies, and these are so gradual that it is difficult to determine definitely the boundaries. Further, owing to the tendency of many of the shrub species to form dense local growths by the development of stems from underground shoots, the smaller associations are very diverse in different parts of the same society.

Birch-vaccinium society.—This mixed society of bog shrubs occupies about one-fourth the area of the bog. Its substratum consists of peat standing about a foot above the average water level. The dominant plants are Betula pumila, Vaccinium corymbosum, Rubus frondosus, Aronia nigra, Vaccinium canadense, and Pteridium aquilinum. Just as common perhaps, but of lower growth, are Rubus hispidus, Spiraea salicifolia, S. tomentosa, Aralia hispida, Chamaedaphne calyculata, and Rumex Acetosella. The ground covering, except beneath the dense shade of the shrubs, is made up of Polytrichum juniperinum. There are many small areas of which this plant now holds exclusive control, and forms a rich carpet of

green, yellow, and red, depending upon the season of the year. Where the moss is disturbed by the uprooting of plants, the substratum becomes exceedingly dry. The moss dies out, and in place of it there springs up a growth of Cladonia rangiferina, C. pyxidata,

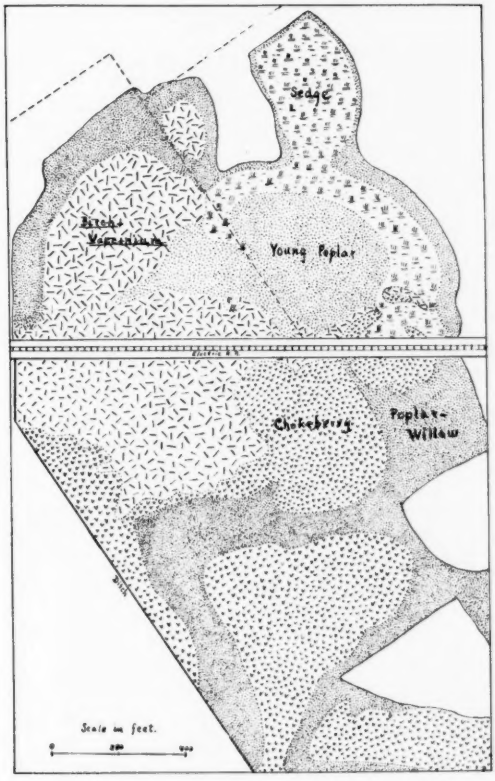


FIG. 11.—Chelsea bog.

C. gracilis, C. verticillata, C. cristatella, and frequently a small admixture of Rumex Acetosella. These plants gradually close over the surface and aid in the conservation of the moisture. As the conditions become more favorable, the Polytrichum again closes over the area, driving out the lichens. About the borders of the shrubs

the Polytrichum is killed out by the shade. Rumex Acetosella is better fitted to withstand such conditions, and consequently forms an inner border about each group of shrubs. Where depressions occur and are flooded for any length of time, the Polytrichum is replaced by Eriophorum virginicum and Scirpus cyperinus. Along the northwestern border Rubus nigrobaccus is making inroads upon this society. To the north of the railroad, however, the most important changes are being wrought by the development of Populus tremuloides and Quercus velutina. Young trees of the former are now scattered throughout, while the latter is present in small number. The plants of minor importance are Ilex verticillata, Viburnum lentago, Ilicioides mucronata, Amelanchier Botryapium, Euthamia graminifolia, Doellingeria umbellata, Bidens trichosperma tenuiloba, Dulichium arundinaceum, Poa flava, and Sphagnum cymbifolium.

Chokeberry society.—Aronia nigra forms the most dense and exclusive growth that occurs on the bog. Usually the substratum is somewhat lower and more subject to overflow than in the last society. It would seem from observation that this condition is in part due to the chokeberry itself. Owing to its dense growth, it protects the surface of the peat from drought and favors the processes of decay. At the same time it adds very little to the substratum in the way of débris. Where it attains its best development it is practically without undergrowth. About the borders it is mixed with Vaccinium corymbosum, Betula pumila, and Ilex verticillata. Of the smaller plants, Pteridium aquilinum penetrates to the greatest distance. Other species occurring about the borders are mentioned among the other societies.

Poplar-willow society.—About the borders of the bog, and extending to a greater or less extent into its interior, is a dense zone composed of Populus tremuloides, Salix discolor, Quercus velutina, Populus grandidentata, and Salix nigra. By far the most abundant form is the trembling aspen. The substratum varies from areas well above the water level to areas which are constantly submerged. The aspen is also the most important of the plants which are invading the shrub societies. In the relative proportion of the individual species there is the greatest variation at different places in this border zone. Of the more enduring species, Quercus velutina is the most abundant. The other species present are Salix Bebbiana, S. sericea, S. lucida,

Prunus serotina, Quercus alba, Q. macrocarpa, Acer rubrum, Betula lutea, Amelanchier Botryapium, Viburnum pubescens, Spiraea salicifolia, S. tomentosa, Corylus americana, Sambucus pubens, Cornus candidissima, C. stolonifera, Cicuta maculata, Aster lateriflorus, Carduus altissimus, Galium asprellum, Osmunda cinnamomea, O. regalis, Ranunculus pennsylvanicus, Calamagrostis canadensis, Viola blanda, Euthamia graminifolia, Bidens frondosa, and Aster Novae-Angliae.

Sedge society.—On the northeast side of the bog is an area dominated by sedges. In the fall of the year it appears to be a uniform area of Scirpus cyperinus, but there are many other species mixed with it. The substratum is low and is mainly characterized by tussocks formed by the sedges. Throughout, occur small clumps of the willows already mentioned. The most abundant accessory species are Isnardia palustris, Calamagrostis canadensis, Carex teretiuscula, C. stipata, C. filiformis, C. fusca, C. oligosperma, C. riparia, and Aulacomnium palustris.

The future flora of this bog appears to be indicated by the rapid growth of the poplars, willows, and oaks. The few tamaracks remaining are approaching maturity and are not being reproduced. The means by which these tree species combat the shrubs is mainly by shading, while the latter in the same way interfere with the development of the tree-seedlings. The time involved in this struggle must be very great, but the ultimate outcome will be an oak forest, the intervening stages being filled in by poplar and willow growths. If, however, the decay of the peat beneath these trees brings the surface to the water level, the poplar-willow stage will be indefinitely prolonged.

GENERAL CONSIDERATION OF THE BOG FLORA.

Beside the trees mentioned in the preceding descriptions, note should be made of the occasional occurrence of the black ash, Fraxinus nigra, and swamp white oak, Quercus platanoides, in bog areas. It frequently happens, when the tamaracks are cut, that the black ash becomes abundant, as in the area one-half mile southeast of Kavanaugh Lake, where it is now associated with Ulmus americana and Acer rubrum. Another example occurs about a mile north of Chelsea in the NE. ¼ Sec. 1, Sylvan Tp. Here in a small area from which the tamaracks were removed, Fraxinus nigra, Quercus platanoides,

Fraxinus americana, F. pennsylvanica, Acer rubrum, Ostrya virginiana, Tilia americana, and Liriodendron tulipifera are associated. The undergrowth consists of Solidago patula, S. neglecta, Aster lateriflorus, Mitella diphylla, Euonymus obovatus, Viola pubescens, Agrimonia hirsuta, Cornus florida, C. candidissima, Eupatorium perfoliatum, Rosa Carolina, Viburnum Lentago, Juniperus communis, and Spiraea salicifolia. The substratum is almost entirely occupied by mosses, including Hypnum fluitans, H. Schreberi, H. Blandovii, H. roseum, Thuidium recognitum, and Climacium americanum.

On the farm of James Barton (SW. ¼ Sec. 2, Lyndon Tp.) the black ash, red maple, and American elm have replaced a former growth of tamaracks and black ash.

In a previous publication (**55**: p. 403) the writer called attention to the absence of a genetic relationship between the bog plants and the surrounding vegetation in southern Michigan. This was explained on the basis that the bog vegetation is a relict of former climatic conditions; that it has a genetic relationship with the conifer forest formation of northeastern North America, as shown by studies in northern Michigan and Pennsylvania, and that in this region it has been surrounded by a more southern flora whose center of distribution is the southeastern United States. Consequently no order of succession between the tamarack and the oak floras is to be expected.

When, however, bog areas are cleared or their normal development disturbed, such trees as the black ash, white ash, red maple, and elm replace the tamarack, and a definite order of succession is established.

It was also maintained that present bog habitats are continuations of similar habitats which came into existence when a colder climate prevailed than at present. More recent observations tend to confirm and strengthen this statement.

The dominance of bog and swamp plants respectively in adjoining areas is to be explained largely by the time when the areas came to support their present ground vegetation. If the habitat has existed undisturbed since the time when a colder climate prevailed, the bog plants will be dominant. If it came into existence in recent times, or has been disturbed, it will be dominated by swamp species.

(*To be concluded.*)

BRIEFER ARTICLES.

TOLERANCE OF DROUGHT BY NEAPOLITAN CLIFF FLORA.

(WITH THREE FIGURES)

THE writer has already made mention of several of the most abundant species on the cliffs in the vicinity of Naples.[1] Some of these plants seemed to offer sufficient points of interest to be worthy of more detailed study, and a few notes in regard to their summer condition are here offered.

At Pozzuoli, where most of these observations were made, the strip of fertile soil which skirts the beach is bounded on the landward side by cliffs, in many places quite vertical, rising to a height of thirty to more than a hundred meters. These cliffs are occasionally of trachyte, but most frequently of gray or yellowish tufa, which in softness and porosity closely resembles the softest brick used in interior construction by American builders. Decomposed it makes a moderately rich and very warm soil. The chemical composition of two such tufas (from the little island of Vivara, 8.3 miles (13^{km}) from Pozzuoli, of the same volcanic series and not greatly different age from the Pozzuoli deposits) is as follows:

	Gray Tufa	Yellow Tufa
SiO_2	51.08	45.50
Al_2O_3	13.71	16.05
Fe_2O_3 / FeO	13.16	11.69
MgO	4.72	3.20
CaO	7.09	5.03
Na_2O	2.94	2.28
K_2O	2.94	4.12
H_2O	4.58	9.36
CO_2	.....	1.50
Cl	.....	0.40
	100.22	99.13

On account of the porosity and the vertical extent of these tufas, the soil water sinks to great depths, springs (except profound volcanic ones) are unknown, and the southerly faces of the cliffs during the summer months appear perfectly dry.

	July	August
Mean daily temperature, ° C.	24.14	23.96
Mean precipitation, mm.	19.12	23.88

[1] BOT. GAZETTE **35**: 360–362. 1903.

During the summer of 1904 the maximum temperature at 2 P. M. observed in the superficial layer of soil on the little local deposits of weathered earth on the faces of cliffs, was 57° C.

Occasionally the month of July is quite rainless.

Some experiments on the amount of moisture contained in the material of the faces of tufa cliffs and walls gave the following results:

1904		Loss of moisture at 100° C., per cent.
Aug. 15.	Top of Roman pillar of brick and tufa, portion about ultimate rootlets of *Medicago arborea*	2.1
Sept. 1.	Earth on face of cliff about ultimate rootlets of *Artemisia variabilis*	10.6
Sept. 8.	Earth on face of cliff about ultimate rootlets of *Matthiola rupestris*	13.4
Sept. 9.	Earth on face of cliff about ultimate rootlets of *Artemisia arborescens*	5.4
Sept. 10.	Tufa-like clay, surface of cliff, no vegetation except *Sedum* sp.	0.7

These determinations were made at a time when the autumn rains had not as yet set in, and the tufa and earth examined were nearly at their minimum as regards moisture-content. A few light sprinkles during late August and early September had not materially affected their condition.

In the cliff-side formations about Pozzuoli the most important woody species, arranged roughly in the order of their abundance, are:

1, Artemisia arborescens, L.; 2, A. variabilis, Ten.; 3, Helichrysum rupestre, DC; 4, Inula viscosa, Ait.; 5, Spartium junceum, L.; 6, Medicago arborea, L.; 7, Opuntia Ficus-Indica, Mill.; 8, Mesembryanthemum acinaciforme, L.; 9, Matthiola rupestris, Guss.

Number 5 of this list has been much discussed as a typical summer deciduous xerophytic shrub, and so it did not seem worth while to investigate further its equipment for resisting the difficulties of its environment. Numbers 7 and 8, the succulent members of the formation, are not indigenous and might better be studied in detail in their original habitats. Of the other members of this little flora it may be said that in general they have not the aspect of extreme xerophytes. It therefore seemed likely to be a profitable bit of work to look into the qualifications which enabled these six species to support the very high summer temperature to which they are exposed, with, in general, an inadequate supply of water.

In external appearance the only obvious characteristic common to most of the shrubs considered is the tufted form of the plant. Helichrysum and Matthiola show this well in the shape of the plant as a whole

(*fig. 1*) and the Artemisias in the shape of the separate branches. It seems probable that this mode of growth is of use in removing the foliage of the plants as far as possible from the intensely heated cliff surfaces.

The plants in question show few adaptations for extraordinary collection or storage of water. The roots of the Artemisias are often twice or more than twice as long as their stems, but the other four species have comparatively short roots. In all six species the means of checking foliar transpiration are only moderately developed. Most of them during the rainy season transpire abundantly. The loss per hour per 100 square centimeters of leaf surface (reckoning lower surfaces only) for Matthiola is 661^{mg}, Helichrysum 750^{mg}, Medicago 1200^{mg}, and Inula 1431^{mg}, at a temperature of about 30° C., when the moderately xerophytic leaves of the olive lose 450^{mg} per hour. The leaf areas for the finely dissected leaves of the Artemisias were difficult to calculate, so twigs of these were compared with olive twigs by weight, and the loss per gram per hour of both species of Artemisia was found to be about 190^{mg} when the loss of an olive twig was 60^{mg}.

FIG. 1.—*Helichrysum rupestre* (left), *Matthiola rupestris* (right). May condition.

Putting the means of checking transpiration in tabular form, they may be indicated as follows:

...COLORADO...
STATE NORMAL SCHOOL
GREELEY, COLORADO

	Leaves summer deciduous	Leaves withering	Leaves paraheliotropic	Leaves sulcate or revolute	Leaves very hairy or sericeous	Leaves aromatic with essential oil
Artemisia arborescens	..	×	..	..	×	×
Artemisia variabilis	..	×	..	..	..	×
Helichrysum rupestre	..	×	..	×	×	×
Inula viscosa	..	×	..	..	..	×
Medicago arborea	×	..	×	..	..	..
Matthiola rupestris	..	..	..	×	×	..

No one of the nine cliff species enumerated is without some xerophytic characteristics, but it is noteworthy that only two of the non-succulent species have ample and obvious protection from injury by drought. The Spartium, leafless during the drier months and with thick wax-coated epidermis and sunken stomata, endures months of rainless heat without injury. The Medicago (*figs. 2, 3*)[1] has a far less xerophytic aspect, but it flourishes not only on the nearly vertical surfaces of tufa cliffs, but also on the bare tops of ancient Roman walls and pillars. It is, indeed, the characteristic shrub of the meager flora of these latter localities, often at a height of 10–20^{m} above the ground and far beyond the reach of any moisture from the soil. Its roots are short and scanty, and the plant contains no mechanism for special storage of water, but the complete shedding of the leaves in early summer renders the shrub secure against fatal desiccation afterward. Unfortunately I was not able to make as many determinations of the rate of transpiration of *M. arborea* under various conditions, as would have been desirable, so the following values are far from exact; still they may serve to explain the tenacity of life of the species. The total transpiration per hour at 30° C. of a twig 8^{cm} long was about as follows:

May 1, leafy twig in water	180^{mg}
May 14, leafy twig in water	120
June 17 leafy twig in water	70
September 14, leafless twig, not in water	5

In the first case above given, the leaves were in the height of their activity; May 14 they looked as green and fresh as at first, but had lost a little of their power to transpire. By June 17 all the leaves had turned yellowish and had taken up permanently their paraheliotropic position. On September 14 the twigs were (and had long been) entirely leafless and appeared rather destitute of moisture. The figures speak for themselves, and the final rate of transpiration, less than 3 per cent. of the maximum,

[1] For these figures the author is indebted to Mrs. HERBERT S. JENNINGS.

indicates an extremely high degree of adaptiveness to variations in temperature and water supply. The greatly lessened loss of water from the leafless twig of September 14 was certainly in great measure due to its comparatively desiccated condition at the beginning of the half-hour during which it was allowed to transpire. Twigs in vigorous leafy condition (May 14) lost about 7 per cent. as much water through the cortex alone as through leaves and cortex taken together.

It is evident that *Medicago arborea* depends for protection against the excessive transpiration mainly upon its summer-deciduousness. This is shown not only by the lessened loss of water after defoliation, as above stated, but also by the fact that in damp soil, as under large trees of *Quercus Ilex* at Lake Fusaro, where during the larger part of the day in summer the illumination is only from 1 to 5 per cent. of the total, the leaves of this species are hardly at all deciduous during the summer. The aspect of these shade plants (*fig.* 2) is notably different from that of those growing on cliff sides. The former are much taller and relatively more slender, with leaves fewer, larger, and longer petioled. Twigs of shade plants gave about one and one-half times as much leaf area as those of equal length from sun plants. Leaves on individuals growing in deep shade were less numerous than on those growing in

FIG. 2.—*Medicago arborea*, shade form, grown in a situation with one to five per cent. illumination. $\times\frac{3}{4}$.

the sun, but each leaf of the former class was about twice as large as one of the latter.

Like those of a good many other Leguminosae, the leaves of this Medicago take a paraheliotropic position (*fig. 3*) during the hours when they are exposed to bright sunlight. This is identical with the nocturnal position. The movements of the leaflets are so sluggish that it is difficult to ascertain definitely the percentage of illumination necessary to induce the position. As already stated, the leaves take this attitude permanently for some time before they are shed for the summer.

FIG 3.—*M. arborea*, mesophytic form grown in full sunlight; leaflets in paraheliotropic position. $\times\frac{3}{4}$.

Of the other woody non-succulent plants under discussion, the Matthiola alone at the end of the dry season has suffered no material injury. It is difficult to see how this plant, with its not inconsiderable rate of transpiration and its leaves destitute of unusual epidermal protection and with loose, soft mesophyll, maintains itself so successfully during the Mediterranean summer. Its most xerophytic characteristic is the manner in which the leaves are folded together upward along the midrib.

The Helichrysum has a decidedly xerophytic aspect. Its cylindrical looking linear leaves are 30–70^{mm} long and usually only 1.4–1.5^{mm} wide; sometimes 3^{mm} wide. Both surfaces, but especially the lower, are covered with an abundant coating of felted, cobwebby hairs, and in leaves of the narrower type the spaces between the midrib and the recurved leaf margins are quite filled with a mass of hair. But this apparent provision against excessive transpiration, as already shown, does not prevent rapid loss of water, and indeed the poorly developed epidermis and loosely packed cells of the mesophyll are ill adapted to retain water. Helichrysum and Inula both lose more than half of their foliage by drying up before the end of the summer, and many of their branches die to the ground. The Artemisias also lose by drying *in situ* sometimes more than two-thirds of their leaves, but the branches generally remain alive.

All four of these species appear to occupy their cliff-side stations rather because the latter are somewhat free from other competing shrubs than because here is found an ideal environment. Indeed, the Artemisias and the Inula in good soil have a robuster habit and more abundant foliage than along the faces of the tufa cliffs where their presence is most characteristic.

Summing up the results of the observations made upon the nine species dealt with in this paper, the members of this flora may be classed according to their qualifications to endure high temperature with deprivation of water as follows:

Succulents, extremely resistant . . .	*Opuntia Ficus-Indica* *Mesembryanthemum acinaciforme*
Uninjured by drought, retaining all foliage	*Matthiola rupestris*
Summer deciduous, highly resistant . .	*Spartium junceum* *Medicago arborea*
Leaves and branches often dying *in situ*, moderately resistant	*Artemisia arborescens* *Artemisia variabilis* *Helichrysum rupestre* *Inula viscosa*

—J. Y. Bergen, *Naples, Italy.*

A NEW GENUS OF OPHIOGLOSSACEAE.

(WITH ONE FIGURE)

During the spring of 1903 the writer discovered the gametophytes of *Botrychium obliquum* Muhl., and later announced the fact in a catalogue of the pteridophytes of Minnesota.[1] Since that time both sporophyte and gametophyte of this and other species of Botrychium have been subjected to careful study. The gametophytes of *Botrychium virginianum* have been found in large numbers, and a few gametophytes of *B. simplex* and *B. matricariaefolium* were found in 1904. While the results of the investigation are not ready for final publication, it seems at the present time desirable to call attention to the embryo of *Botrychium obliquum*, as it affords evidence bearing on a question now being agitated by others. In two recent papers Campbell[2] has disputed Bower's contention that the Ophioglossaceae are allied to the Lycopodiales. Campbell would derive them directly from the Bryophyta.

The gametophytes of *Botrychium obliquum* are subterranean and destitute of chlorophyll. They grow by a distinct apical meristem, are

[1] Minn. Bot. Studies **3**:249. 1903.

[2] (1) American Naturalist **38**:761–775. 1904; (2) *ibid.* **39**:273–285. 1905.

flattened dorsiventrally, and possess many long rhizoids. They are monoecious. The reproductive organs are developed on the flattened dorsal side and in their organization differ essentially from those of *Botrychium virginianum* as described by JEFFREY.[3]

The oosperm upon segmentation does not develop directly into a spherical protocorm, as is the case in all other ferns which have been studied, but *first gives rise to a long suspensor*, which burrows into the tissue of the gametophyte in the manner characteristic of certain lycopod embryos. At the tip of this suspensor a spherical protocorm is organized, out of which the stem and root apices are shortly differentiated. The axis of the metacorm transfixes the protocorm and all the tissue of the latter, except the suspensor, becomes a permanent part of the metacorm. The embryo does not, therefore, possess a lateral cotyledon (nursing-foot) as does *Botrychium virginianum*. The root grows downward and *emerges from the under side* of the gametophyte, and at a later period the first leaf breaks through the upper surface. The relation of the members in the young embryo and its orientation in the gametophyte are well illustrated by the accompanying figure.

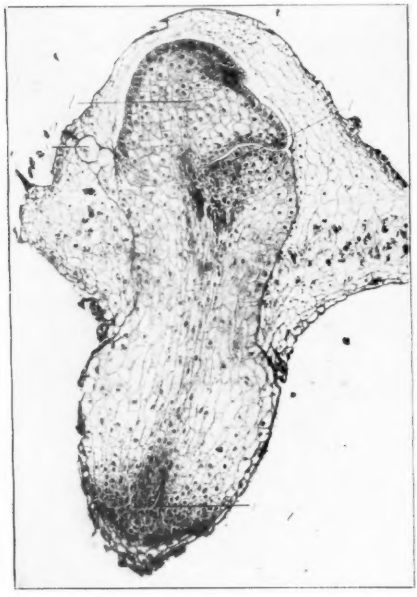


FIG. 1.—Photomicrograph of a section through a gametophyte and young sporophyte of *Sceptridium obliquum*. The section is vertical, and transverse of the gametophyte. The root is already protruded from the under side of the gametophyte, while the position of the first leaf was marked by a pronounced elevation on the upper side. *a*, archegonium; *s*, suspensor; *t*, stem tip; *l*, first leaf; *r*, root. × 60.

A study of the mature sporophytes of the ternate species of Botrychium

[3] Univ. of Toronto Studies 1:1–32. 1898.

discloses unique characters which alone mark them as a natural group entitled to generic rank. Considering, in addition, the anomalous character of their embryos as illustrated by *Botrychium obliquum*, it appears at once desirable to segregate them as a distinct genus.

The writer would therefore suggest the name **Sceptridium** (from σκῆπτρον), in allusion to the scepter-like sporangiophore.

SCEPTRIDIUM, a new genus of Ophioglossaceae.

Stem subterranean, short, erect, with many clustered roots. Sporophyll *dividing near the stem* into a long petioled sporangiophore and a shorter petioled sterile segment. Sporangiophore erect, bi-, tri-, or even quadripinnate, bearing naked, spherical sporangia in two rows. Sterile segment inserted obliquely near or at the surface of the ground, ternately divided or compound. Gametophyte tuberous, subterranean, saprophytic, monoecious. Embryo *with a suspensor* and without a pronounced lateral cotyledon; its axis straight, *the root emerging from the lower side* of the gametophyte.

To this genus should be referred the following described but ill-defined species and varieties:

Sceptridium australe (R. Br.).—*Botrychium australe* R. Br., Prodr. Fl. Nov. Holl. 164. 1810.

Sceptridium biforme (Colenso).—*Botrychium biforme* Colenso, Trans. New Zeal. Inst. **18**:223. 1886.

Sceptridium biternatum (Lam.).—*Osmunda biternata* Lam., Encyc. Meth. Bot. **4**:650. 1797. *Botrychium biternatum* (Lam.) Underw., Bot. Gazette **22**:407. 1896.

Sceptridium californicum (Underw.).—*Botrychium californicum* Underw., Torreya **5**:107. 1905.

Sceptridium Coulteri (Underw.).—*Botrychium Coulteri* Underw., Bull. Torr. Bot. Club **25**:537. 1898.

Sceptridium daucifolium (Hook. & Grev.).—*Botrychium daucifolium* Hook. & Grev., Ic. Fil. **2**: *pl. 161.* 1831.

Sceptridium decompositum (Mart. & Gal.).—*Botrychium decompositum* Mart. & Gal., Mém. Acad. Sci. Bruxelles **15**:—(15). *pl. 1.* 1842.

Sceptridium dissectum (Spreng.).—*Botrychium dissectum* Spreng. Anleit. **3**:172. 1804.

Sceptridium japonicum (Prantl).—*Botrychium daucifolium β japonicum* Prantl, Jahrb. Bot. Gartens Berlin **3**:340. 1884. *Botrychium japonicum* (Prantl) Underw., Bull. Torr. Bot. Club **25**:538. 1898.

Sceptridium Jenmani (Underw.).—*Botrychium Jenmani* Underw., Fern Bull. **8**:59. 1900.

Sceptridium matricariae (Schrank).—*Osmunda matricariae* Schrank, Baier. Fl. **2**:419. 1789. *Botrychium matricariae* (Schrank) Spreng., Syst. Veg. **4**:23. 1827.

Sceptridium obliquum (Muhl.).—*Botrychium obliquum* Muhl., Willd. Sp. Pl. **5**:62. 1810.

Sceptridium obliquum elongatum (Gilbert & Haberer).—*Botrychium obliquum elongatum* Gilbert & Haberer, Fern Bull. **11**:89. 1903.

Sceptridium obliquum Habereri (Gilbert).—*Botrychium obliquum Habereri* Gilbert, Fern Bul. **11**:88. 1903.

Sceptridium obliquum intermedium (Underw.).—*Botrychium obliquum intermedium* Underw., Our Native Ferns, ed. 6, 72. 1900.

Sceptridium obliquum oneidense (Gilbert).—*Botrychium ternatum oneidense* Gilbert, Fern Bull. **9**:27. 1901.

Sceptridium pusillum (Underw.).—*Botrychium pusillum* Underw., Bull. Torr. Bot. Club **30**:50. 1903.

Sceptridium robustum (Rupr.).—*Botrychium rutaefolium* var. *robustum* Rupr., Milde Nov. Act. Acad. Caes. Leop.-Carol. **26**:763. 1858. *Botrychium robustum* (Rupr.) Underw., Bull. Torr. Bot. Club **30**:51. 1903.

Sceptridium Schaffneri (Underw.).—*Botrychium Schaffneri* Underw., Bull. Torr. Bot. Club **30**:51. 1903.

Sceptridium silaifolium (Presl).—*Botrychium silaifolium* Presl, Rel. Haenk. **1**:76. 1825.

Sceptridium subbifoliatum (Brack.).—*Botrychium subbifoliatum* Brack., U. S. Expl. Exped. **16**:317. 1854.

Sceptridium tenuifolium (Underw.).—*Botrychium tenuifolium* Underw., Bull. Torr. Bot. Club **30**:52. 1903.

Sceptridium ternatum (Thunb.).—*Osmunda ternata* Thunb., Fl. Japon. 329. 1784. *Botrychium ternatum* (Thunb.) Sw., Schrader's Journ. Bot. **1800**^{2}:111. 1801.

Sceptridium Underwoodianum (Maxon).—*Botrychium Underwoodianum* Maxon, Bull. Torr. Bot. Club **32**:220. 1905.

—HAROLD L. LYON, *University of Minnesota.*

CURRENT LITERATURE.

BOOK REVIEWS.

Photomicrographs of plant rusts.

THERE is a difficulty in studying microscopic fungi, from which the student of phanerogamic plants is exempt. It arises from the minuteness of the parts, making it necessary to prepare a slide and place it under the microscope, and sometimes more than one slide, before the essential characters can be seen. As only one slide can be examined at a time, the student must carry a mental picture of the various forms previously examined which he desires to compare with the one under examination. He cannot lay his two or more objects side by side and have them both or all equally under consideration at the same time.

One of the best known means for reducing this difficulty to a minimum is the use of photomicrographs. When skilfully prepared under uniform conditions and magnification they are of great assistance in making close comparisons between a few forms, and immensely facilitate the rapid review of a large series.

Recognizing these facts, together with the additional one that many species are so rare that the student can not hope always to secure a specimen, Professor E. W. D. HOLWAY, of the University of Minnesota, has undertaken to publish a complete series of photomicrographs of the spores of the North American rusts.[1] The work starts out with the genus Puccinia, taking the species up systematically according to hosts. The first number begins with the order Ranunculaceae, having seventeen species, followed by nine other orders. The 45 species of this first number are illustrated by 62 figures, all but one representing the spores as seen in the field of a microscope under a magnification of 250 diameters. The photogravure plates show almost the same perfection of detail as the original photographs, both being of superior quality.

The text accompanying the plates is of the nature of a monograph. Each species is fully described, with synonymy, distribution, and citation of *exsiccati*. The work is all founded upon the specimens and treatises in the herbarium of the University of Minnesota, and is carried out with much critical insight.

The number forms a highly valuable addition to the literature of the plant rusts, and especially so on account of the illustrations, few botanists having such skill in the production of photomicrographs as the author.—J. C. ARTHUR.

Luther Burbank.

THOSE who know Mr. Burbank personally admire his gentle and simple character; they who know his work acclaim him as a genius in plant breeding

[1] HOLWAY, E. W. D., North American Uredineae, Vol. I, part 1. 4to. pp. iii+32. *pl. 1–10.* Minneapolis, 1905. $2.00.

and marvel at his dauntless and unselfish devotion thereto; they realize that he has operated on a grand scale, producing, by his acute judgment and his keen insight, even more than by skilful and ingenious manipulation, remarkable and valuable results. He is a great man—doubtless the greatest—in his chosen field; granting that he is now worthy a biography, he is most unfortunate in his biographer.[2]

To describe the personality of a great man one must not only be enamored of the man, but be able to sketch him in attitudes of mind and soul that carry conviction of greatness. To exhibit the work of a great man, one must not only be conversant with the details of the work, but be able to make manifest its nature and its bearings, its problems, and its triumphs.

Mr. HARWOOD is convinced that LUTHER BURBANK is a superlatively great man; but he cannot compel his readers to believe this by mere reiterated assertion. He is sure that the work is marvelous and of surpassing value; but as he obviously knows nothing of horticulture and less of botany, he is incompetent to explain it. He insists *ad nauseam* that Mr. BURBANK is a scientific luminary of the first magnitude; but our author has no inkling of the meaning of scientific training, nor does he know the criteria of a man of science; he does not even perceive that his liberal (and presumably literal) quotations convict his hero of some lack of the scientific spirit, which is even more important than the errors they embody.

Given reasonably clear English and a logical presentation, the actual information in this book could be condensed into a magazine article. It is surprising that a house like the Macmillan Co. should lend its imprint to a volume with the style and English of a sensational newspaper, not to mention consistent misspelling which cannot be laid at the door of the compositor.

As to the work of BURBANK little need be said. Its economic value is unquestionable, even though many of the most wonderful things are not yet quite perfected. And no one will doubt the devotion and few will question the altruism of this man, who like AGASSIZ, has been too busy to make money, except for further prosecution of his work. But withal it must be recognized that he is no "wizard of horticulture;" he has no secrets but skill and insight derived from long experience; he has devised no unusual methods and developed no essentially new ideas in plant breeding. Naturally when he claims to have disproved this scientific theory or that, one hears his opinion and, without doubting his sincerity, remains incredulous until the proof is adduced. If that can be done none sooner than scientific men will recognize and acclaim it. But incredulity is only aggravated by assertion without evidence, and distrust can only be intensified by such absolute misconception of so clear a theory as that of DEVRIES.—C. R. B.

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[2] HARWOOD, W. S., New creations in plant life. An authoritative account of the life and work of Luther Burbank. 12mo. pp. xiv + 368. New York: The Macmillan Co. 1905. $1.75.

Organography

THE LARGE English edition of the second part of GOEBEL'S *Organography of plants* has now appeared.[3] The first part has become so indispensable to students of experimental morphology that the translation of the second has been awaited with much interest, and with some impatience as time wore on. As the German edition was reviewed in this journal shortly after its appearance in 1900,[4] little need now be said about the subject matter. The work, as a whole, is an attempt to present the configuration of plants from the point of view of function and environment. While the first part is primarily a discussion of principles, the second is devoted to a more detailed presentation of the structures and variations of the Bryophyta, Pteridophyta, and Spermatophyta. The wide experience of the author in experimental work, and more especially his great wealth of first-hand observation of plants under most diverse conditions, has enabled him to present a mass of detailed information that is of very great value and suggestiveness.

The translation has been accurately done by Professor BALFOUR. "Spermophyta" will strike everyone as a novel form, but it has classical usage as justification and its brevity will probably cause it to displace the more familiar Spermatophyta. The translator has taken wise liberties with the typographical form, by making headings and subheadings that present the matter more clearly to the eye. When he alters the order of figures, however, we think he goes a bit too far. Other points of make-up are open to objection. If the translation had been made into two volumes of nearly equal size, by dividing at the section on Pteridophyta and Spermophyta the work would have been more convenient to handle than in one thin (270 pages) and one thick (708 pages) part. The separate pagination, and calling the volumes "parts," together with the separate numbering of figures seem to us distinct bibliographical mistakes.

The index is very complete and adds greatly to the value of this translation. The index to illustrations should have been made a part of it. Two indexes are never as good as one.—W. B. MCCALLUM.

Mosses and ferns

THE EXHAUSTION of the edition of CAMPBELL'S *Mosses and ferns* and the continuing demand for it have given opportunity for a thorough revision,[5] made necessary by the researches of the last decade. With the experience gained from a first edition, the author who undertakes a second, unhampered by "plates,"

[3] GOEBEL, K., Organography of plants, especially of the Archegoniatae and Spermophyta. Authorized English edition by ISAAC BAYLEY BALFOUR. Part II. Special Organography. Imp. 8vo. pp. xxiv+708. *figs.* 417. Oxford: Clarendon Press. 1905. $7.00.

[4] BOTANICAL GAZETTE **31**:204. 1901.

[5] CAMPBELL, D. H., The structure and development of mosses and ferns (Archegoniatae). 8vo. pp. vii+657. *figs.* 322. New York: The Macmillan Co. 1905. $4.50.

may reasonably be expected to perfect his book to the limit of his powers, embracing the opportunity not only to bring the work up to date, but also to eliminate crudities of design and execution, well-nigh inseparable from a first edition.

These expectations, unhappily, are not fully met in the revision of *Mosses and ferns*. This is the more disappointing in that the volume is indispensable, both because it is unique in its field, and because of certain undeniably excellent features. These have become well known, and we do not recount them because they are so. They are transmitted, undiminished, to the present edition.

That the book is fairly brought up to date goes without saying, though one may differ from the author as to relative values among some of the newer researches, and may wish that some of the old figures had been replaced by new and better ones. In the bryophyte portion there is less change than among the chapters on pteridophytes, because among the mosses the researches have been fewer and less important. This is shown by space comparisons:

	Pages		Approximate percentage increase	Figures		Approximate percentage increase
	1st Ed.	2nd Ed.		1st Ed.	2nd Ed.	
Bryophyta.....	217	228	5	107	123	7
Pteridophyta.....	290	333	15	155	199	25
Totals.....	519	606	$16\frac{3}{4}^{6}$	266	322	21

In the bryophytes there are no notable changes of view;. in the pteridophytes there are some; but on the whole the author believes that later investigations have confirmed his earlier views. The Isoetaceae have been removed from their association with the Marattiaceae and placed after the Lycopodineae, but other large groups hold the same position as in the first edition. The most extensive revision appears in the section on the eusporangiate ferns, where particular attention is paid to the work of Bower.

Some new material is here published for the first time, but it is mostly taken (with due acknowledgment to others) from papers previously published. A new chapter on the nature of alternation of generations discusses the probable origin of the liverwort thallus, the origin and evolution of the sporophyte, and presents the arguments for homologous and for antithetic alternation, the author giving his adherence to the latter theory. He reiterates the opinion also, that the weight of evidence is in favor of a genetic connection of Pteridophyta with Bryophyta, through Anthocerotes. There is also a new chapter on fossil archegoniates, in which Scott's results figure largely.

Some inaccuracies of the first edition are corrected and some persist. Thus, in an attempt to correct the curious error as to the annulus of the moss capsule, the author doubles it on p. 210, but leaves it in the adjacent figure and on p. 213 in its Simon-pure form. The obviously misleading account of the megaspo-

[6] Greater than either part on account of added chapters.

rangium of Azolla is also retained (p. 414). "Recent" still appears in referring to papers, recent when the first edition was issued in 1895 (*e. g.*, Waldner 1887, Guignard 1889, Buchtien 1887), but now rather ancient.

In style and method of presentation the second edition has no advantage over the first. So far as typography affects it, there seems to be almost ingenuity in selecting for chapter headings and especially for subheads, the most confused and, to a novice, confusing forms. Thus, interpreted by accepted typographical canons, *The biology of the Marchantiales* is a subhead under MONOCLEA; and THE ACROGYNAE is a subhead under ANACROGYNAE, and coordinate with ANELATEREAE and ELATEREAE. Citation of bibliographical references in subheads is awkward and is a new blemish, *e. g.*,

LYCOPODINEAE (*Potonie* (3); *Scott* (1); *Solms Laubach* (2)).

The bibliography, to whose enlargement and completeness the author refers in the preface, would have profited by greater care. Not only are there numerous mistakes in the text-references, one paper being cited when another is meant, but there are papers cited in the text which do not appear in the bibliography at all. Five such cases came to light by pure chance—GARBER, PORSILD, ASHWORTH, BAUKE, and GRAND' EURY; how many could be found by searching we know not. As a minor, but not trifling, matter may be mentioned the unsystematic mode of writing citations; *e. g.*, in the same page four of BOWER'S *Studies in the morphology of spore-producing members* are cited thus:

Roy. Soc. Phil. Trans., vol. clxxxv: 1894, p. 473.
London, 1896. [Nothing more.]
Phil. Trans. Roy. Soc., series B, vol. 189: 35–81, 1897.
Phil. Trans., ser. B., vol. 192: 29 138, 1899.

A like variety can be found in the citation of journals. There are traces of a self-consistent system, however, which hardly goes beyond the adoption, from the one most widely used in America, of its most unimportant feature—the colon following the volume number!

Proof-reading throughout the volume has been very bad, for much of which the printing office and the publishers are blameworthy, but not for all.

The index is really absurd. It is charitable to believe that the author farmed this out to an inexpert hand, and what he did not do to spoil it by sins of omission and commission, the compositor did by ingenious disarrangement of a too complex system of indention. *E. g.*, "Hepaticae" (a curious entry when there are 150 pages about them) has thirty-nine bare entries; its subordinate phrase "germination of spores" has one, and "spores" one (the same), while the spores and their germination are referred to dozens of times in the text. "Acrogynae" has five entries, but "Acrogenous liverworts" in the next line has one, and that is not among the five! "Affinities" has only two sub-references, Matonia and Monoclea, whereas almost every large group has under it in the text a conspicuous subhead, like *Affinities of the Musci*, and so on.

In fact, the revision everywhere shows evidences of haste, and as the author signs his preface April 1905, just before he sailed for Europe on his way to South Africa, it seems likely that he was working under pressure that prevented—most unfortunately, indeed—that "careful revision" of which he speaks.

Spite of defects that, by a little more care, the author could easily have avoided, we welcome the new edition and commend it to every botanist as a necessary reference work, even though he have the first.—C. R. B. and C. J. C.

MINOR NOTICES.

IN AN ELEGANT work on the Bahama Islands,[7] published by the Geographical Society of Baltimore, there is an interesting ecological presentation of the vegetation by W. C. COKER, the result of an expedition undertaken in the summer of 1903. The discussion of the plant formations follows accounts of previous botanical work in the Bahamas, the composition and relationships of the flora, and the economic plants. On New Providence Island the author found a sand strand formation made up of the following associations successively inward: *Ipomoea pescaprae* with Paspalum and Sporobolus, Uniola and Tournefortia, Pithecolobium and Salmea, Erithalia and Reynosia, and the silver palm. There are wet and dry pine barrens, the former with an undergrowth of *Inodes palmetto*, the latter with a Coccothrinax. Other formations are those of the salt marsh, the fresh marsh, the coppice, and the rocky shore. On Watlings Island Suriana, Chrysobalanus, and Lantana are prominent on the sand strand, and there are mangrove formations with Conocarpus. The paper closes with a list of the plants collected. There are plates of typical formations, and of some economic plants, and there is a colored plate of Bougainvillea.—H. C. COWLES.

A POPULAR account of all the pteridophytes except the homosporous Filicales, with special attention to ranges, habitat, time of fruiting, manner of growth, folk lore, etc., is given by CLUTE in a new book entitled *The fern allies of North America*.[8] The field notes, which show an intimate acquaintance with the life histories of the various forms, will interest the botanist as well as the layman. The seven keys, by which the genera and species may be identified are as untechnical as an efficient key can be made. Necessary technical terms are defined in a glossary. Both common names and scientific names are given. No attempt is made to treat internal anatomy or morphology.

The illustrations, more than 150 in number, are by IDA MARTIN CLUTE. Details which are of taxonomic importance have been drawn with particular accuracy, so that many of the species might be identified by the illustrations alone.—CHARLES J. CHAMBERLAIN.

[7] COKER, W. C., Vegetation of the Bahama Islands. The Bahama Islands. pp. 185–270. New York. 1905.

[8] CLUTE, W. N., The fern allies of North America north of Mexico. 8vo. pp. xiv + 278. New York: Frederick A. Stokes. 1905. $2.00 net.

BELIEVING that insufficient attention has been given to the higher fungi as a cause of disease in animals, GUÉGUEN[9] has compiled a volume containing descriptions of all fungi which have been reported parasitic on man and other animals. The material, including the Myxomycetes, is arranged in the following order: Myxomycetes, Oomycetes, Basidiomycetes, Ascomycetes, and Fungi Imperfecti. To the description of each species are added notes on the pathology of the organism so far as known. All fungi that have been reported on animals, even the lowest, are included. Full references to literature are given at the end of each chapter. The volume as a whole will be of greater interest to pathologists than to botanists.—H. HASSELBRING.

HALLIER[10] has published a résumé of the more important features of his natural system of classification[11] with some corrections and additions, which are here noted. The Hydnoraceae and Balanophoraceae are held to be derived through parasitism from epiphytic Cactaceae; the Gnetaceae do not belong to the gymnosperms, but are reduction forms near the Loranthaceae, Myzodendraceae and Santalaceae; and Casuarina is nearly related to Betula and Alnus.—C. J. CHAMBERLAIN.

NOTES FOR STUDENTS.

IN A NOTE in the Comptes Rendus,[12] RÉNÉ MAIRE summarized the results of his cytological study of the mitosis in the ascus of *Galactinia succosa*, describing the existence of "protochromosomes," or chromatic granules formed during the prophases of the first division, and which united during the metaphase into the four chromosomes of the equatorial plate. In a more recent publication,[13] based upon a more detailed study of Galactinia as well as several other Ascomycetes, MAIRE has endeavored to explain the significance of the protochromosomes and to recognize certain specific characters of the first division in the ascus. He believes this division to be heterotypic, comparable to the heterotypic division of higher plants. The secondary nucleus of the ascus at the time of its greatest size shows long, fine, much intermixed chromatic filaments, which have been furnished to it by the two primary nuclei. Later these chromatic filaments approach and fuse two and two. It has been impossible to determine whether or not this bivalence is a result of a folding of a single thread or of the union of two different filaments. At this time the filaments are collected to one side of the nucleus into a compact synaptic ball, which later undergoes complete dissolution into chromatic granules or protochromosomes. At the time the centrosomes and the

[9] GUÉGUEN, F., Les champignons parasites de l'homme et des animaux. 8vo. pp. 299. *pls.* 10. Paris: A. Joanin & Cie. 1904. 20fr.

[10] HALLIER, H., Neue Schlaglichter auf das natürliche System der Dikotyledonen. Phylogenetische Betrachtungen. Imp. 8vo. pp. 15.

[11] BOT. GAZETTE **35**:223. 1903.

[12] Compt. Rend. Acad. Sci. Paris **137**:769. 1903.

[13] MAIRE, RÉNÉ, Recherches cytologiques sur quelques Ascomycétes. Ann. Mycol. **3**:123–154. *pls.* 3–5. 1905.

internuclear aster appear, these protochromosomes leave the achromatic substance, being attracted about four centers to form the four definite chromosomes. Each of the four definite chromosomes undergoes a longitudinal fission, the two halves of which separate at the metaphase, undergoing a new longitudinal splitting during their passage to the poles. This second split is often very distinct during the anaphase of this division, when eight chromosomes may be counted. During the prophases of the second division eight chromatic elements reappear, which unite two and two to form the definite chromosomes of the equatorial plate. The two halves of each chromosome separate, four passing to each pole. The first division of the ascus MAIRE believes therefore to be preceded by a true synapsis, very similar to that described by STRASBURGER for *Thalictrum purpurascens*. He believes the protochromosomes should be interpreted as the gamosomes of STRASBURGER. The segregation and re-collection of the chromatin of two primary nuclei assures a complete rearrangement of the chromatin in the definite chromosomes of the secondary nucleus. MAIRE designates the fusing nuclei as primary and the resulting fusion nucleus or ascus nucleus as secondary. These phenomena, together with the longitudinal splitting preceding the metaphase of the first division, and the longitudinal fission during the metaphase of the second division, which split is much more complete than in phanerogams, all show that the first mitosis in the ascus is heterotypic, analogous to the first division of all normal spore mother-cells, while the characters presented by the second mitosis are those of a homotypic division. MAIRE further believes that the third division is a typic one, where the spirem directly segments into the four chromosomes, which only divide at the metaphase. The proof that the first division in the ascus is heterotypic certainly favors the view that the numerical reduction of chromosomes occurs immediately after the fusion which produces the nucleus of the ascus. This hypothesis finds support in the fact that the number of chromosomes in the mitoses in the ascus and in the ascogenous hyphae is the same as in *Pyronema*. MAIRE has not been able to count the chromosomes of the ascogenous hyphae. He admits the fact that the number of chromosomes may vary in different species of the Ascomycetes, just as this number varies in higher plants, instead of being always four as he has previously maintained. In *Galactinia succosa* the centrosomes and the spindle have an intranuclear origin, while the polar radiations have an extranuclear origin, developing independently of the intranuclear part of the achromatic figure. The ascus presents the cytological characters of secreting cells. In the epiplasm are found basiphile granules entirely distinct from the metachromatic granules, and often a sort of latex. The nucleus is able to take an active part in the elaboration of certain secretory products.—J. B. OVERTON.

A RECENT paper by FISCHER[14] on the Cyanophyceae, while reaffirming in the main his earlier conclusions,[15] presents some further additions to the cytology

[14] FISCHER, A., Die Zelle der Cyanophyceen. Bot. Zeit. **63**[1]: 51–130. *pls. 2.* 1905.

[15] FISCHER, A., Untersuchungen über den Bau der Cyanophyceen und Bakterien. Jena. 1897.

of this group, a subject which is already overburdened with the results of much speculation rather than careful and accurate observation.

FISCHER's results on the microchemical detection of certain substances in the cell are far from convincing, since a comparison with the opposed results of other authors leads rather to a realization of our needs of trustworthy microchemical tests for distinguishing certain carbohydrates and proteids than to FISCHER's conclusions It is not at all demonstrated that FISCHER is able even to distinguish with certainty between a carbohydrate and a proteid substance, although he seems to be perfectly sure of his test.

A new test is given for glycogen, which FISCHER designates as the "tannin-safranin stain." He regards glycogen as the first visible product of assimilation. This is produced in the Cyanophyceae in such large quantities that, although in some instances 75 per cent. of the cells of a filament may be using up this food-substance in active division, there is always left a surplus which is stored up in the "central body." In large species, *e. g.*, *Oscillatoria princeps*, the central body is large enough for the storage of a considerable amount of unchanged glycogen, which in the treated sections assumes the form of large granules and irregular masses.

FISCHER's test for glycogen in this instance may be called into serious question, since the majority of writers on this subject interpret these same bodies as of a proteid nature and not carbohydrate. We are left in serious doubt, in fact, as to whether FISCHER's glycogen granules are to be referred to the albuminous "slime globules," or to the "chromatin granules" of earlier authors, both of which bodies may be readily detected in the "central body" of the larger Oscillatorias.

FISCHER concludes on the other hand, that in the smaller forms, the limited room for storage necessitates the condensation of the glycogen, hence it is here converted into another carbohydrate, "anabaenin," which is stored up in the central body, either in the form of *Zentralkörnern* or as "pseudomitotic" loops. The number of these twisted rods is in some instances apparently constant, and, further, their similarity to chromosomes and their equal division between the two daughter cells arises, according to FISCHER, from the striving, not after an equal distribution of valuable material, but only the distribution of "lästigen Ballast"!

The author thinks that it is probable that this "carbohydrate mitosis" may be the forerunner of the nuclear mitoses of such low forms. At first it is merely a ballast-divider; but later, nuclein might be deposited, and then the central body would assume the true nuclear character. But FISCHER denies emphatically that the central body as it is at present is a nucleus; nevertheless he would agree that nuclein-like substances also occur in the Cynophyceae, but holds that they exist in a finely divided state in the cytoplasm and are not yet formed in special bodies. He thus returns to the old, much-exploited view of the scattered or distributed nucleus. Such scattered nuclein bodies he fails to show, however, in any of his figures.—EDGAR W. OLIVE.

ITEMS OF TAXONOMIC INTEREST are as follows: N. L. GARDNER (Univ. Calif. Publ. Bot. **2**:169–180. *pl. 18.* 1905) has described a new genus (*Nigrosphaeria*) of ascomycetous fungi, parasitic on Pseudhydnotria, one of the Tuberaceae.—N. L. BRITTON (Bull. N. Y. Bot. Garden **4**:115–127. 1905), in a second paper entitled "Contributions to the flora of the Bahama Islands," has described new species of Coccolobis, Caesalpinia, Canavalia, Hibiscus, Heliotropium (2), Lantana (2), Cestrum, Stemmodontia, and Anastraphia.—W. A. MURRILL in his twelfth paper on the Polyporaceae of North America (Bull. Torr. Bot. Club **32**:469–493. 1905) has described twelve new genera of this family (*Irpiciporus, Dendrophagus, Spongiporus, Rigidiporus, Earliella, Cubamyces, Coriolellus, Microporellus, Flaviporellus, Aurantiporellus, Auranticporus, Pycnoporellus, Phaeolopsis*), making new names for species formerly referred to Boletus, Polyporus, Fomes, or Trametes. Earliella alone is possibly new.—K. K. MACKENZIE (*idem* 495–506) describes three new varieties and creates two new specific names under Onosmodium, and refers *O. Thurberi* to *Macromeria Thurberi*.—In a sixth paper on Crataegus (Rhodora **7**:162–164. 1905) C. S. SARGENT describes two new species of Tomentosae.—M. L. FERNALD (*idem*) refers the common *Symphoricarpos racemosus* Auct., with leaves glabrous beneath, to the new var. *laevigatus;* those with leaves pilose beneath to the type, and those with leaves whitened beneath to var. *pauciflorus*.—A. BORZI establishes (Nuova Notarisia **16**:20. 1905) two new genera of Chrococcaceae, *Planosphaerala* and *Bacularia*.—W. A. SETCHELL describes (*idem* 59–63) a new genus, *Peyssonneliopsis*, a parasitic alga distributed under a manuscript name in 1903, as no. 649 of the Phycotheca Boreali-Americana.—MAX FLEISCHER (Hedwigia **44**:301–329. 1905) describes as a new genus of the Indian Archipelago, *Aerobryopsis*, to receive ten species mostly belonging to a section of Neckera, Eriocladium, which, though preoccupied, was raised to generic rank by DUSÉN. A dozen new species, all issued in Exsicc. Musci Archipel. Ind. Series VII. 1904, are also described.—F. BUBÁK and E. KABÁT (*idem* 350–358) describe new species of fungi from Bohemia; Phyllosticta (3), Vermicularia (1), Ascochyta (3), Diplodina (1), Leptothyrium (4), and Ramularia (1).—H. CHRIST (*idem* 359–370) publishes the list of ferns collected by ULE in the Amazon region, including one new species each of Elaphoglossum, Polypodium, Pteris, Lindsaya, Asplenium, Aspidium, Alsophila, and Danaea.—The whole of the first part of vol. 38, Engler's Bot. Jahrb., is devoted to descriptions of new species of African plants. The following new genera are established: by R. SCHLECHTER (Bot. Jahrb. **38**:1–56. 1905) *Auxopus, Genyorchis* (Orchidaceae), and *Neoschumannia* (Asclepiadaceae); by H. HARMS (*idem* 74–79) *Platycelyphium* and *Stemnocoleus* (Leguminosae); by A. ENGLER (*idem* 94–101) *Dicraeanthus, Winklerella* (Podostemonaceae) and *Tridesmostemon* (Sapotaceae).—C. R. B.

IN THE large literature on Bordeaux mixture, secondary physiological effects on plants, not due to the fungicidal action of the mixture, have frequently been described. These effects are of two kinds: first, a stimulating effect, resulting

in darker green, thicker foliage, with increased starch production and decreased transpiration; second, direct toxic action on the foliage and fruits. The whole question, on which many conflicting views have been published, has been critically examined by SCHANDER.[16] Many writers have attributed the stimulating action of Bordeaux mixture to the entrance of small quantities of copper into the plant, both through the cuticle and through the stomata. SCHANDER finds that leaves injected with a solution of $CuSO_4$, 1 part in 10,000,000, and allowed to lie in the solution 24 hours, showed poisonous effects, while much more concentrated solutions were unable to penetrate the uninjured epidermis when applied externally. The argument is that the cuticle prevents the penetration of very dilute solutions of copper, such as might result from solution of the particles of copper compounds applied to the leaf, but if any copper enters the cells the results are injurious, never stimulating. By growing plants in water cultures with dilute solutions of copper, it was found that the young roots were gradually killed, whereupon another crop of roots was formed, which also was finally killed, etc. Here again there was no stimulating action, although the top of the plant remained uninjured, showing that the copper was accumulated by the root cells, even from very dilute solutions, but was not passed on into the vascular system. In soils, a more concentrated solution of copper was required to produce toxic effects on account of their absorption. By appropriate experiments it is also shown that neither the lime compounds nor the traces of iron produce stimulating effects.

The true explanation of the phenomena is found in the physical action of the coating itself. The same results were produced by shading plants with glass to which a spray of Bordeaux mixture had been applied, also by the use of thin paper or dust. Good results were obtained only in bright sunny weather, while injury resulted during cold rainy seasons. This, no doubt, explains the conflicting reports of various investigators. The toxic effect of the mixture is found to be due to solution of the copper, caused by the secretions of glandular hairs as in the peach, phaseolus, and sunflower.—H. HASSELBRING.

THE FINAL sections of DAVIS's *Studies on the plant cell*[17] have appeared. Section IV deals with cell unions and nuclear fusions. The subject is treated under three heads: (1) protoplasmic connections between cells, (2) sexual cell unions and nuclear fusions, and (3) asexual cell unions and nuclear fusions. The writer says, "The test of a sexual act must lie with the history of the elements which fuse. If they are shown by their morphology and developmental history to be sexual cells or gametes, then their fusion becomes a sexual process." Asexual unions and nuclear fusions are treated under three heads: (1) cell fusions which have apparently no sexual relations, (2) cell fusions which are substitutes for a normal ancestral sexual process now suppressed, and (3) extraordinary modifications of

[16] SCHANDER, R., Ueber die physiologische Wirkung der Kupfervitriolkalkbrühe. Landw. Jahrb. **33**:517–584. 1904.

[17] DAVIS, B. M., Studies on the plant cell. Amer. Naturalist **39**:217–268, 449–499, 555–599, 695–740. 1905.

what may have been originally sexual processes but which at present serve some peculiar and special function.

Section V deals with cell activities at critical periods of ontogeny in plants. The literature is discussed under the headings, apogamy, apospory, hybridization, and xenia. Historical accounts are given, but most of the space is devoted to cytological papers of the last three or four years. About 150 papers are cited in the bibliography. Section VI, which concludes the series, is entitled "Comparative morphology and physiology of the plant cell." The material is treated under the heads: the simplest types of plant cells, comparisons of the structures of some higher types of plant cells with simpler conditions, some apparent tendencies in the evolution of mitotic phenomena, the essential structures of the plant cell and their behavior during ontogeny, and the balance of nuclear and cytoplasmic activities in the plant cell.

The series as a whole contains a fuller treatment of the subject than that given in KOERNICKE'S recent paper, *Der heutige Stand der pflanzlichen Zellforschung*.[18] The writer's personal views are expressed freely throughout the work. The bibliography of recent literature is quite complete.—C. J. CHAMBERLAIN.

LANG[19] has studied the structure and development of Cyathodium, a tropical genus of Marchantiaceae. The few species occur in the deep shade of tropical forests, in dark caves, in the crevices of walls, or even on paths in more exposed positions. The two forms studied (*C. foetidissimum* Schiffn. and *C. cavernarum* Kunze) were collected in the Malay Peninsula and the material was preserved in alcohol. One interesting feature of the investigation was that it made possible a comparison between one of the least reduced and the most reduced form in the genus. The antheridia are borne on small disk-shaped antheridiophores, developed from the lower surface of the thallus, and at maturity are essentially similar to those of other Marchantiaceae. LEITGEB'S surmise that the antheridial wall is not formed of a layer of cells was definitely set aside for both species. In both species the archegonia stand on the morphologically upper surface of the thallus, in *C. cavernarum* actually retaining this position, but in *C. foetidissimum* becoming displaced so as to appear to be borne upon the under surface. The development of the sporogonium in the main resembles that of other Marchantiaceae, the sporogenous tissue and the greater part of the wall of the capsule being derived from the epibasal cell, and the foot and the base of the capsule wall being derived from the hypobasal cell. The four cells at the base of the foot grow out into a number of relatively long tubular processes, each of which may branch once or oftener, thus greatly increasing the absorbent surface of the foot. The conclusion is reached that the supposed close relationship of the genus with Targionia is confirmed; and that it is probably a reduction group of species,

[18] See BOT. GAZETTE **39**: 30–31. 1905.

[19] LANG, WILLIAM H., On the morphology of Cyathodium. Annals of Bot. **19**: 411–426. *pls. 21–22.* 1905.

derived from a form not unlike Targionia by adaptation of the gametophyte to shady and damp situations, and by changes in the sporogonium induced by the alterations in the gametophyte.—J. M. C.

DRIMYS, a genus of the Magnoliaceae, and a neighboring genus, Trochodendron, have long been known to resemble gymnosperms in the structure of their wood, which consists entirely of tracheids with bordered pits. HALLIER, in his recent scheme of phylogeny, places Drimys in the Drimytomagnoliaceae, an hypothetical group of the Magnoliaceae derived from the Bennettitales or nearly related Cycadales. A paper by STRASBURGER[20] gives the results of a study of the ovule, embryo sac, fertilization, and endosperm and early stages in the development of the embryo of *Drimys Winteri*. In all these particulars the development is that of a typical angiosperm, with not the slightest suggestion of gymnosperm characters!

STRASBURGER takes this occasion to express his views as to the nature of the endosperm and embryo-sac structures. The formation of endosperm is still regarded as a continuation of an interrupted development of the prothallium, the fusion of polar nuclei which precedes it being a secondary phenomenon. In the usual development of the embryo sac the two polar nuclei lie in a mass of cytoplasm surrounded by a common plasma membrane. Under such conditions it is usual for nuclei to fuse. The synergids are not regarded as eggs, but rather as cells of the prothallium. The condition found in the ovules of Gnetum is not regarded as a forerunner of the condition found in the embryo sacs of angiosperms. Gnetum is rather the last member of a line of development.—CHARLES J. CHAMBERLAIN.

WIESNER has recently written several papers on leaffall,[21] one of which, on summer leaffall, has been reviewed in the BOTANICAL GAZETTE.[22] A second paper deals with *Trieblaubfall*, or leaffall in connection with the development of leaf buds, and of course found only in evergreens. This type of leaffall is associated with ombrophily, a habit characteristic of essentially all evergreens. The external factors which so strongly influence leaffall in summergreens are of little account here. The third paper treats of frost leaffall. If the absciss layer freezes, the leaf drops at once, but if the rest of the leaf freezes, while the absciss layer remains unfrozen, leaffall occurs more slowly. In some cases leaffall is due to high turgescence in the cells of the absciss layer. The final paper is a presentation of the biological significance of leaffall, and the author's conclusions are the result of many years of investigation. Leaffall is absent in plants where

[20] STRASBURGER, E., Die Samenanlage von *Drimys Winteri* und die Endospermbildung bei Angiospermen. Flora **95**:215–231. *pls. 7–8.* 1905.

[21] WIESNER, J., Ueber den Treiblaufall und über Ombrophilie immergrüner Holzgewächse. Ber. Deutsch. Bot. Gesells. **22**:316–323. 1904. Ueber Frostlaubfall nebst Bemerkungen über die Mechanik der Blattablösung. *Idem* **23**:49–60. 1905. Die biologische Bedeutung des Laubfalles. *Idem* **23**:172–181. 1905.

[22] BOT. GAZETTE **38**:153. 1904.

leaves and stems die simultaneously, as in ephemerals, most annuals and biennials, and monocarpic plants generally. Leaffall is absent in most herbs, and present in most woody plants, especially in those which require much light in connection with bud development; this light is secured when the leaves have fallen. Leaffall is less pronounced or even absent in woody plants whose buds never lack sufficient light. Leaffall occurs in woody plants after injury or death, or when they develop in conditions where normal functions cannot be performed.—H. C. COWLES.

CHANDLER[23] has examined the "seedlings" of a number of ferns, mostly belonging to Polypodiaceae. In nearly all the cases studied a protostele was found to pass into the condition of siphonostele or dictyostele by the appearance, inside the xylem of the central cylinder, first of phloem, then of endodermis, and lastly of fundamental tissue which communicates at the foliar gaps with the fundamental tissue of the cortex. Usually several leaf traces are given off before the central cylinder incloses fundamental tissue, and at this level the core of the central cylinder consists of phloem. The writer concludes that "the primitive type of vascular system in the ferns is a solid rod of vascular tissue, which may be a solid xylem strand surrounded by phloem, or an amphiphloic strand." The writer follows JEFFREY in considering the parenchymatous pith of the central cylinder to be of the same morphological nature as the cortex; curiously enough he hesitates to apply this generalization to certain species of Osmunda, though he considers the rule to hold good for *O. cinnamomea*. The results of the investigation seem to confirm the view that the ontogeny of the vascular system resembles what has probably been its phylogeny. The change from a solid to a tubular central cylinder is attributed to the necessity for an efficient attachment of the leaf traces. The mode of origin of double leaf traces in several genera is carefully described, and well represented in the plates accompanying the paper.—M. A. CHRYSLER.

Within the past few years, Dr. LUJO ADAMOVIČ has published a number of papers dealing with the plant geography of Servia. A recent contribution[24] has to do with the sand steppes of that country. This is not a single unified formation, but comprises a group of formations, similar in ecology, distribution, and life-history. Meadows contain hygrophiles, grasses which form close mats, and there are but few annuals or coarse herbs; steppes, on the contrary, contain xerophiles, and there are many annuals and coarse herbs; heaths are in places where soil and air are wet, and they contain half-shrubs, among which a single species often dominates. The life-history of the sand steppes is interesting. Sand commonly encroaches on vegetation, but the reverse is the case in wet years.

[23] CHANDLER, S. E., On the arrangement of the vascular strands in the "seedlings" of certain leptosporangiate ferns. Annals of Bot. **19**:365–410. *pls. 18–20.* 1905.

[24] ADAMOVIČ, L., Die Sandsteppen Serbiens. Engler's Bot. Jahrb. **33**:555–617. 1904.

The pioneer plant of the drifting sand is the delicate annual, *Polygonum arenarium;* a Veronica and a Tragopogon are other early plants. No grasses appear among the pioneers, though a Festuca appears the second year, with a Euphorbia; before long, these later species form mats and exclude the first named. When the dunes have become well covered with vegetation, and rather thoroughly established, they are termed *Sandpussten.* Plants found exclusively in sand are termed psammophytes, while those found elsewhere but preferring sand are termed psammophiles. The photographs accompanying the paper well illustrate the dunes and the *Pussten.*—H. C. COWLES.

A SERIES of five papers by BROWN and ESCOMBE record the fundamental researches made by these investigators at Kew during a period of three years. The paper here cited[25] is the largest of the series and to it the others are supplementary. Part I is descriptive of apparatus devised by the authors for accurately determining the amount of CO_2 in air before and after photosynthesis. The rate of photosynthesis as determined by the direct measurement of CO_2 entering was found to be one-third to one-fifth that found by SACHS with his method of increase in dry weight. When all sources of error were accounted for, the discrepancy was reduced to 50 per cent. An investigation of SACHS's method shows that the errors are cumulative, so that it is very unreliable. The estimation of foliar respiration as made by the authors agrees with that made by BLACKMAN. An investigation of the "energetics" of the leaf shows that only a small part of the radiant energy incident upon a leaf is used for photosynthesis, the "economic coefficient" being only 6.5 per cent. in full sunshine. Even in moderate light the supply of photosynthetic energy is far greater than the leaf can use. The surplus of energy which the leaf is compelled to absorb is dissipated by the vaporization of water in transpiration and by the thermal emissivity required in the constant adjustment of the temperature of the leaf to that of the surrounding air.—RAYMOND H. POND.

AT THE suggestion of Professor WITTROCK, HESSELMAN[26] undertook the completion of an investigation begun by STENSTRÖM, but broken off upon the latter's death in 1901. Having noticed that in Sweden southern slopes are often covered by pines, and northern slopes by spruce, and that birch woods ascend higher on sunny than on shady mountain slopes, STENSTRÖM determined upon a careful study of the distribution of plants on slopes of various directions. He chose for this study railway embankments, because they present similar soils and all kinds of slopes. The results obtained were very uniform, southern slopes having chiefly xerophiles or weeds (such as *Anthemis tinctoria, Convolvulus arvensis, Barbarea vulgaris*), and northern slopes having a more closed and

[25] BROWN, H. T., and ESCOMBE, F., Researches on some of the physiological processes of green leaves, with special reference to the interchange of energy between the leaf and its surroundings. Proc. Roy. Soc. B. **76**: 29–112. 1905.

[26] HESSELMAN, H., K. O. E. Stenström's Studier öfver Expositionens Inflytande på Vegetationen. Arkiv för Botanik **4**: 1–54. 1905.

mesophytic vegetation (with *Aira cespitosa*, *Ranunculus acris*, etc.). No differences of moment were observed between east and west slopes. Although no close study of factors was made, it was clear that the direct influence of radiation, or its influence on moisture and temperature, is the controlling element. A figure is given of a valley in Lapland with a wood of birch with scattered pine and spruce on the southern slope, and a tundra with *Salix herbacea*, *Andromeda hypnoides*, and other characteristic forms on the northern slope.—H. C. COWLES.

SALMON has extended his investigations on the specialization of parasitism in the Erysiphaceae to include the ascospores of several forms.[27] In former experiments with conidia it was found that conidia from *Bromus commutatus* would infect *B. hordeaceus* but not *B. racemosus* or *B. mollis*. *B. hordeaceus*, however, acts as a "bridging species," so that if conidia from *B. commutatus* are used to inoculate *B. hordeaceus*, the conidia produced on *B. hordeaceus* will in turn infect *B. mollis*. A similar specialization occurs in the ascospores. Ascospores from *B. commutatus* infect *B. hordeaceus*, but not *B. racemosus*. The conidia produced from the former infection were then used to infect *B. mollis*.

Another series of experiments was performed in order to see whether *E. graminis* from wheat, which also infects *Hordeum silvaticum*, could by continuous culture on *H. silvaticum* be made to lose its power of infecting wheat. The fungus was cultivated for five generations on Hordeum, but showed no signs of losing its power of infecting wheat. Successive generations of the fungus on Hordeum seemed to show a weaker power of infecting that plant, but this is probably explained by the fact that only the younger leaves of Hordeum are susceptible to infection.—H. HASSELBRING.

OLIVER and TANSLEY give a detailed account of their methods for surveying vegetation, applicable where the ground is reasonably flat.[28] The two methods employed, the method of squares and the gridiron method, are related, and their especial advantage is to exhibit the characteristics of an area where the vegetation is complex and yet definitely related to physiographic features. These methods have been employed in the salt marshes of the north coast of Brittany, and in some respects resemble the quadrat methods used by CLEMENTS. The method of squares is employed for mapping on the scale of 1:250 or 1:500, squares one hundred feet each way being made from a base line; such squares correspond to a five-inch square in the notebook. The gridiron method is used for detailed work, an area twenty-five feet square being measured out; this area is then divided off by tapes into smaller areas, 5×25 feet. Here six inches correspond to one-tenth of an inch in the notebook, so that great accuracy can be secured. The methods could be advantageously modified by the use of metric units and relations.

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[27] SALMON, E. S., On specialization of parasitism in the Erysiphaceae. III. Ann. Mycol. **3**:172–184. 1905.

[28] OLIVER, F. W., and TANSLEY, A. G., Methods of surveying vegetation on a large scale. New Phytol. **3**:228–237. 1904.

On the maps, samples of which are given, physical features are represented by continuous lines, plant associations by dotted lines, and contour lines by alternating dots and dashes.—H. C. COWLES.

THE RELATIONS of *Arum maculatum* with insects, as described by HERMANN MÜLLER and others, have become so much a part of the literature of entomophily that it is a distinct shock to read the testimony of GERARD,[29] as given at a recent meeting of the Linnean Society. The current account is contradicted as follows: "The obstruction caused by the hairs is not such as of itself to prevent the insects escaping;" for "the hairs are not stiff or sharp; they do not point consistently downwards; frequently they are not in the narrow throat of the tube; they are so far apart as to leave ample room for such small insects [as those that habitually visit the plant] to pass between them; they never extend to the walls of the chamber, leaving a free passage in that direction;" and, besides, insects may be observed to escape. That many insects do not escape is evident, which the observer explains as follows: "The truth seems to be that the plant drugs the insects, reducing them to a state of imbecility, which is the true cause of their inability to get away; and that finally they not only die from the effects of the treatment, but their succulent portions are absorbed by the Arum, which thus claims to rank as carnivorous."—J. M. C.

IN A PAPER entitled *Evolution of cellular structures* COOK and SWINGLE discuss some of the fundamental problems of plant cytology.[30] The treatment is interesting for their arrangement of the material, and for the development of a terminology covering the various phases of the life histories of plants based upon the nuclear conditions. Whether such elaborate systems of nomenclature really tend to clearness of expression may be open to question. They are apt to give the framework of a subject a degree of rigidity, which is found to be impracticable because it cannot yield. In a number of points their outline seems open to criticism. The statement that "there has been no evolution away from sexuality" is surprising, when one recalls the wonderful development of the kelp family, of Caulerpa, and of numbers of forms whose reproductive processes are entirely asexual, together with the remarkable extent of apogamy. The establishment of apogamy in such large and successful genera as Alchemilla, Hieracium, Antennaria, Taraxacum, and Thalictrum, indicates the possibility of apogamy in higher plants to an extent that is probably scarcely suspected.—B. M. DAVIS.

DETTO has joined the army of investigators who are taking up anew the floral color problem as related to insects.[31] In view of the experiments of FOREL,

[29] GERARD, JOHN, *Arum maculatum* and its relations with insects. Jour. Botany **43**:231–233. 1905.

[30] COOK, O. F., and SWINGLE, W. T., Evolution of cellular structures. Bull. 81. Bureau Plant Indus., U. S. Dept. of Agric. 1905.

[31] DETTO, C., Versuche über die Blütenorientirung und das Lernen der Honigbiene. Flora **94**:424–463. 1904.

ANDREAE, GILTAY, and BUTTEL-REEPEN, he regards color attraction as established in the case of Apis and Bombus. However, the experiments of GILTAY and BUTTEL-REEPEN show that color becomes less and less a source of attraction, when bees become acquainted with the neighborhood which they frequent. Again the visits of bees to flowers that are not showy indicate that high coloration is not absolutely necessary to secure the visitation.

WERY also has attempted to find out the exact value of color as source of attraction for bees.[32] She finds that flowers with colored organs attract bees more than do flowers of the same species without colored organs, that honey does not serve to attract bees, that artificial flowers attract bees as well as do natural flowers, and that perfume attracts but little. The author thinks that she has demonstrated that color and form together offer four times as much attraction to bees as pollen, perfume, and nectar combined.—H. C. COWLES.

ADAMS has published[33] another paper on postglacial migration, in which he discusses the successive "waves" of life from the close of the Ice Age until now. After the first or tundra wave, there followed a wave from the western and northeastern centers, consisting of peat bog and conifer forest plants and animals. The third wave was from the southeastern and southwestern centers, migration taking place from the former along the coastal plain and the Mississippi River; from the southwestern center there came desert plants and animals. The paper concludes with general remarks concerning the definiteness of the laws of migration. Invading elements enter a new region at definite places, and they remain in definite associations. The succession of ecological associations is similar even in diverse regions, where the biotic components are different. A particular merit of this paper is that animals and plants are considered together, forming a biota, rather than a fauna or a flora.—H. C. COWLES.

BESSEY has continued his studies on the encroachment of the forest upon the Nebraska prairies.[34] After a general discussion of the factors involved in migration, instances are given of recent natural enlargements of the forest area. Such advances of the forest are to be observed especially where protection is afforded from fires and grazing animals. An especially favorable place for the effective germination of tree seeds is along a forest border in a moist valley, where tall weeds readily develop and choke out the prairie grasses. The forest border may advance from a few feet to several hundred feet in a single year. The paper is accompanied by maps showing the distribution within the state of each of the native Nebraska trees.—H. C. COWLES.

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[32] WERY, J., Quelques expériences sur l'attraction des abeilles par les fleurs. Bull. Acad. Roy. Belgium **1904**: 1211–1261.

[33] ADAMS, C. C., The postglacial dispersal of the North American biota. Biol. Bull. **9**: 53–71. 1905.

[34] BESSEY, C. E., Plant migration studies. Univ. Nebraska. Studies **5**: 1–27 1905.

PAMMEL[35] has given an interesting account of the Iowa species of Gymnosporangium whose aecidium or roestelia stage causes the rust of apple leaves. The species described are: *Gymnosporangium globosum, macropus, clavipes, nidus-avis,* and *clavariaeforme.* A considerable number of inoculation experiments are here reported, showing the genetic relationship between the teleutosporic stage on the red cedar and the roestelia stage on apple and other rosaceous plants. PAMMEL has not secured as good results in combating the apple rust by Bordeaux spraying as was reported by EMERSON.[36] The removal of the cedar-apples is again recommended as the best method of preventing injury from the apple rust.—E. MEAD WILCOX.

SHELDON[37] has published an account of his investigations in West Virginia of the anthracnose of the watermelon, due to *Colletotrichum lagenarium,* and minor notes regarding a few of the other diseases of cucumbers and melons. The anthracnose was successfully combated by spraying with the usual Bordeaux mixture, but the cupram did not give so good results. In a later bulletin,[38] in a way a preliminary hand-book of the diseases of that state, he presents brief notes regarding some of the more important diseases of cultivated plants observed in West Virginia during 1903 and 1904.—E. MEAD WILCOX.

MINSSEN holds[39] that the experiments of BLANCK[40] were faulty in method and his data consequently incorrect, invalidating his conclusion that the diffusion of water in humus soils is retarded by the presence of free humus acids. MINSSEN finds, on the contrary, that neither free humus acids nor other organic or mineral acids in dilute solutions can diminish the rate of diffusion of water or of salt solutions. The physiological dryness of humus soils, then, cannot be due to the free humus acids, nor can these influence plant growth in this particular. —C. R. B.

IN THE *Report of the Botanist*[41] of the Hatch Experiment Station of Massachusetts for 1904 there is given a bibliography of great value to the plant pathologist. It includes, as the title states, "Some important literature relating to dis-

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[35] PAMMEL, L. H., The cedar apple fungi and apple rust in Iowa. Bull. Iowa Exp. Stat. 84:1–36. *figs. 1–11.* 1905.

[36] EMERSON, R. A., Apple scab and cedar rust. Bull. Neb. Exp. Stat. 88:1–21. *figs. 1–9.* See BOT. GAZETTE **40**:149. 1905.

[37] SHELDON, J. L., Diseases of melons and cucumbers during 1903 and 1904. Bull. W. Va. Exp. Stat. 94:119–138. *pls. 1–5.* 1904.

[38] SHELDON, J. L., A report on plant diseases of the state. *Idem* 96:69–99. *pl. 6* (not numbered).

[39] MINSSEN, H., Ueber die Diffusion in sauren und neutralen Medien, insbesondere im Humusboden. Landw. Versuchs-Stat. **62**:445–476. 1905.

[40] BLANCK, Ueber die Diffusion des Wässers im Humusboden. *Idem* **58**:145. 1901.

[41] STONE, G. E., Rept. 17, Mass. Hatch Exp. Stat. **1904**:31–34. 1905.

eases, etc., of crops, not generally believed to be caused by fungi and insects." This constitutes a supplement to the similar list of the literature of diseases due to parasites that was published by STURGIS.[42] Both lists should be bound together for more convenient reference by the working pathologist.—E. MEAD WILCOX.

HANS HALLIER[43] has published a curious, personally flavored account of his scheme of classification of seed plants. It is a statement of his right to be heard, a complaint that his views have been given scant attention or none at all, and a general outline of his scheme. Of course it will be taken up or discarded on its merits, without any reference to personal rights or feelings.—J. M. C.

COOK and HORNE,[44] in the first bulletin of the new Cuban Experiment Station, give the results of a year's study of the insect enemies and certain diseases of tobacco in Cuba: the seed-bed disease due to a species of *Rhizoctonia;* mosaic disease; leaf-spot due to *Cercospora nicotiana;* and an injury due to the parasitism of *Orobanche ramosa.*—E. MEAD WILCOX.

ANDREWS finds,[45] contrary to the results of DEMOOR,[46] that the nucleus cannot divide independently of the protoplasm, and that if the protoplasm is killed or temporarily disabled, the nuclear activity is soon (sometimes immediately) affected.—C. R. B.

TO THE LIST of plants which form chlorophyll in darkness Miss BITTNER adds[47] *Fegatella conica*, various mosses, the reduced leaves on fern rhizomes, the spores of Osmunda regalis, and scales of Selaginella.—C. R. B.

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[42] STURGIS, W. C., Literature of plant-diseases. Rept. 24, Conn. Exp. Stat. **1900**: 255–297. 1901.

[43] HALLIER, HANS, Provisional scheme of the natural (phylogenetic) system of flowering plants. New Phytologist **4**: 151–162. 1905.

[44] COOK, M. T., and HORNE, W. T., Insects and diseases of tobacco. (English edition.) Bulletion Estación Central Agronómica de Cuba 1: 1–23. *figs. 1–20.* 1905.

[45] ANDREWS, F. M., The effect of gases on nuclear division. Annals of Bot. **19**: 521–530. 1905.

[46] DEMOOR, Contribution à l'étude de la physiologie de la cellule. Archives de Biol. **13**: 30–54. 1894.

[47] BITTNER, KAROLINA, Ueber Chlorophyllbildung im Finstern bei Kryptogamen. Oesterr. Bot. Zeits. **55**: 302–312. 1905.

NEWS.

MACMILLAN AND COMPANY announce for publication before Christmas a textbook on plant pathology by Dr. D. T. MACDOUGAL and F. S. EARLE.

PROFESSOR R. THAXTER, of the Cryptogamic Laboratory of Harvard University, is spending his sabbatical year in a collecting trip in South America.

OAKES AMES, R. C. LEAVITT, and A. A. EATON of the Ames Botanical Laboratory, left October 10 for a period of study in British and European herbaria.

DR. FORREST SHREVE, Bruce Fellow in the Johns Hopkins University, sailed from Baltimore on October 13 for Jamaica, where he will spend the year in work on the anatomy and physiology of epiphytes.

THE TWENTY-FIRST annual meeting of the Indiana Academy of Science was held at Shortridge High School, Indianapolis, December 1, 1905, under the presidency of JOHN S. WRIGHT. The program contained twenty papers on botanical topics.

PROFESSOR B. L. ROBINSON has returned to his duties at the Gray Herbarium after spending several months in Europe, where he attended the Vienna Congress and made brief studies in various herbaria. MR. M. L. FERNALD has been promoted to an assistant professorship.

MRS. A. G. HELMER, of Helmer, Georgia, is prepared to send by mail small boxes showing the products of the cotton plant for school and home study. The box contains photographs of the flower, pod, and leaf; a ripe pod with seeds *in situ;* samples of seed after ginning, hulls, meal, crude and refined oil; and a miniature bale of cotton.

PROFESSOR W. A. KELLERMAN will leave before the holidays for Guatemala to continue his mycologic studies begun there last winter. He reports a rich harvest of parasitic fungi and hopes to publish next summer some of the results of the two seasons' work. Several new species are on hand and special phases of the subject are under investigation. Minor commissions of specialists will be gladly executed, so far as feasible; requests should be made immediately.

DR. J. C. ARTHUR, of Purdue University, Lafayette, Indiana, is preparing the manuscript upon the plant rusts of North America for early publication in the *North American Flora.* As this is the first attempt to present the uredineous flora of North America with reasonable completeness, much difficulty is naturally experienced in securing material enough to show approximately the geographical distribution of species. Any assistance, through the gift of duplicate specimens or the loan of herbarium sheets, will be greatly appreciated. The commonest, as well as the rarer species, are desired.

AT THE Desert Botanical Laboratory, Tucson, Arizona, Professor F. E. LLOYD, of Columbia University, spent June and July in a continuation of his

studies on the physiology of the stomata of desert plants. Dr. V. M. SPALDING has returned for his third winter's research work at this laboratory, and is extending his studies on the absorption of water and water vapor by representative shrubs and trees. The resident investigator, Dr. W. A. CANNON, is observing the transpiration of certain salt-loving plants which are growing in the vicinity of Tucson, and continuing his work on the anatomy of *palo verde* (Parkinsonia) and other plants.

ON JULY 15 appeared the first number of the semi-monthly *Repertorium novarum specierum regni vegetabilis*, under the editorial direction of Dr. FEDDE, and from the publishing house of GEBRÜDER BORNTRAEGER. The earlier numbers each contain sixteen pages, filled with diagnoses of new species, some original (South American collections mainly), some reprinted. It is the purpose to reprint in this journal the scattered descriptions of new species from all journals and floras, as published, and to publish original papers of the same kind. The subscription price at present is *M* 10 per year; or for an edition printed on one side only, for card catalogue use, *M* 15.

THE UNIVERSITY OF TEXAS has recently improved its equipment for courses in mycological and bacteriological technique. For the present, only elementary mycology and bacteriology for sanitary engineers are given, but it is intended later to offer advanced courses. Professor W. L. BRAY, head of the School of Botany, is preparing an elementary plant geography of Texas, to be issued as a bulletin of the University of Texas for the affiliated schools. The major part of the bulletin will deal with the factors influencing distribution and the phenomena of adaptation. He is also continuing his study of the forest conditions of the "Big Thicket" country of southeastern Texas. A. M. FERGUSON, instructor in botany, has been endeavoring by experiments on an extensive scale to improve the quality and yield in southern corn, and is investigating the acclimatization of corn races.

DURING the month of September, Professors OLIVER, TANSLEY, and BLACKMAN conducted a field expedition to the Bouche D'Erquy in Brittany, somewhat on the lines of a previous expedition, but more thoroughly carried out, and embracing more points of attack. The place selected both in 1904 and 1905 was an extensive area of salt marshes. The party was divided into three sections: (1) under charge of Professor OLIVER, continuing and contouring the general map of the area, begun in 1904; (2) under charge of Mr. TANSLEY, charting the vegetation, in which work CLEMENTS'S quadrat and transect methods were employed, in addition to the grid system of OLIVER and TANSLEY; (3) under charge of Dr. BLACKMAN of Cambridge, determining the physical factors of the habitats, especially the salt and water factors. It is planned to continue these expeditions in succeeding years, and permanent quadrats have been plotted to facilitate the study of vegetation changes. This study is one of the most practical and systematic yet attempted, and the division of labor amongst the members of the party, each section being under charge of a competent specialist, is particularly commendable.

GENERAL INDEX.

The most important classified entries will be found under Contributors, Personals, and Reviews. New names and names of new genera, species, and varieties are printed in **bold-face** type; synonyms in *italics*.

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